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THE EFFECTS OF METAZOAN PARASITES ON THEIR HOSTS.

By

A. E. SHIPLEY, M.A., F.R.S.,

Fellow and Tutor of Christ's College, Cambridge,

AND

E. G. FEARNSIDES, B.A. (Cant.), B.Sc. (Lond.),

Of Trinity Hall, Cambridge.

THE effect of parasites on their host varies within very wide limits. When but few are present it is often quite negligible, but when many occur the consequences may be most serious. The host is influenced in four ways: (i.) by the mere presence of the parasite in some organ in which it takes up a certain amount of space and displaces a certain amount of tissue; (ii.) by the migration of parasitic organisms from one part of the body to another; (iii.) by the loss to the host, which has to feed the parasite, either on the half-digested contents of its alimentary canal or on its more elaborated fluids; (iv.) by the presence of certain toxins said to be given off by the body of the parasite, either as excretions or otherwise.

(I.) THE INJURY CAUSED BY THE MERE PRESENCE OF THE PARASITE.

The harm caused by the mere presence of the parasite depends largely upon the position it takes up. For instance, a *Cysticercus cellulosae* in the muscles or in the skin causes comparatively little harm, whereas the same organism in the brain or in the eye may produce very serious symptoms. Such cysts may also, as they grow, exert pressure on a blood vessel or on a nerve, and thus cause serious disturbance. A *Filaria nocturna* may be ensconced in some lymphatic vessel or lymphatic gland, and be unnoticed, but if it or its eggs begin to block the lymph vessels, chyluria, elephantiasis and other grave diseases may ensue. Parasites of the lungs, such as *Paragonimus westermani*

cause deep-seated injury to the pulmonary tissue by their presence and by their excretions.

From the point of view of occupying space and causing sympathetic changes in the immediately surrounding tissues the *T. echinococcus* in its larval form is the most dangerous human parasite. In this stage it reaches the size of an orange, and infests chiefly the liver, but it also occurs in the kidneys, lungs, the cranial cavity and other parts of the body, and is the cause of the profound trouble.

(II.) THE INJURY CAUSED BY THE MIGRATION OF THE PARASITE.

The migration of the parasite through the tissues of its host may cause grave disturbances. It is during the migration of the larval *Trichinella spiralis* from the intestine to the muscles, in which they encyst, that the fever and the severe muscular pains are most in evidence. Once encysted in the muscles these symptoms die down.

An *Ascaris lumbricoides* in the intestine may be harmless, but if it pierces the wall of the alimentary canal it may set up fatal peritonitis.

The entrance of the larvae of *Ankylostoma duodenale* and of *Strongyloides intestinalis* into the skin from moist earth or water causes much trouble, and is probably responsible for a dermatitis variously known as "cooley-itch," "sore-feet," "ground-itch," etc. Craw-craw is probably caused by *Rhabditis niellyi*, which exists in pustules in the skin. On the other hand, so large a worm as *Filaria medinensis* can migrate through the tissues from one end of the body to the other without being perceived, but should some accident rupture her pregnant body the myriad larvae, escaping and permeating the blood vessels and tissues cause suppuration and abscesses. The intense irritation set up by the migration, usually shortly after going to bed, of the *Oxyuris vermicularis* is another instance of trouble caused by the movement of parasites, trouble which is of use to the nematode, inasmuch as it induces scratching, and thus leads to auto-infection.

The long, whip-like anterior end of *Trichocephalus trichiurus* sometimes bores through the wall of the alimentary canal, and through the passage thus formed the intestinal contents with their bacteria may ooze. In this way appendicitis and peritonitis may be, according to Metschnikoff,[1] at any rate in some cases, set up.

The parasites of the blood vessels, although considered much more dangerous than those of the alimentary canal, yet move about in the plasma of the blood, and seem to cause little or no harm. Millions of the minute larvae of *Filaria bancrofti* make their way from the

[1] Bull. Acad. Méd., Paris, 1901 (3), xlv, p. 301; and Beiträge f. innere Med. zum 70 Geburtstage von E. V. Leyden, 1902, i, p. 425; and J. Girard, Ann. Inst. Pasteur, 1901, xv, p. 440.

large vessels at the base of the lungs to the peripheral vessels every evening, and every morning retrace their path without apparently in any way hurting their hosts.

(III.) The Injury caused by the Parasite feeding on the Juices of the Host.

The actual loss to the host of tissue and nutritive fluids upon which the parasites feed is comparatively slight. The Cestodes have no mouth and no alimentary canal but live bathed in nutrient fluids which they imbibe through their epidermis, the Trematodes and Nematodes on the other hand digest food in an alimentary canal. Leuckart [1] tells us that a *Dibothriocephalus latus*, seven metres long, weighs 27.5 grms., and that it gives off in a year a number of proglottides which, end to end, measure some fifteen to twenty metres. These may weigh about 140 grms. The weight of this portion is not perhaps a very fair method of estimating the loss of the host, but at least it strongly points to the fact that the loss is very slight compared with the amount of food a human being consumes in a year, and is probably in many cases made good by the increased appetite that the presence of the parasites calls forth. *T. saginata* throws off some eleven proglottides a day, whose yearly weight amounts to about 550 grms.

A female round-worm, *As. lumbricoides*, produces forty-two grms. of eggs every year, and must also extract from the host a certain amount of nutriment for herself besides the amount that goes to build up the ova. When present in large numbers—and Fauconneau Dufresne describes a case in which a boy got rid of five thousand in less than three years, and on one day evacuated six hundred—the loss is certainly serious. *Strongyloides intestinalis*, at one time thought to be the cause of Cochin China diarrhoea, exists in such numbers that it is not uncommon for one hundred thousand to be expelled at one time. Such a number is said to weigh 200 grms. Leuckart, quoting from Normand [2] and Davaine,[3] states that at times even a million individuals may be evacuated. In spite of their small size, it must be some drain on the host to support such numbers as these.

It is, however, especially in children, who require every gramme of their food for their own growth that the loss is appreciable. We have passed from the days when Jordens [4] called intestinal worms "the good angels and unfailing helpers of children."

[1] The Parasites of Man. Edinburgh, 1886, p. 125.

[2] Mem. sur la diarrhoea dite de Cochin China, Paris, 1877.

[3] Traité des Entozoaires, etc., Paris, 2 Edition, 1877.

[4] "Entomologie und Helminthologie des menschlichen Korpers," Hof., 1801. The quotation is from the English Edition of Leuckart's "The Parasites of Man."

(IV.) INJURIES CAUSED BY TOXINS SAID TO BE GIVEN OFF THE PARASITES.

Toxins are said to be given off by Entozoa. This is a subject which just now is being actively worked at in many laboratories, but at present we cannot be said to have reached a definite or final conclusion in this matter, or at any rate one which is universally accepted. Professor Blanchard[1] has recently published an admirable resumé of our knowledge of the toxins produced by animal parasites. From this we have largely borrowed. He sums up on the whole in favour of the view that they play little or no part in the symptoms which arise in their host. Boycott,[2] from experiments with extracts of intestinal worms, also concludes that worm extracts in a coarse way are non-toxic. On the other hand, many of the symptoms are just such as would be produced by the giving off of toxins from the parasites, and there is no doubt that toxic substances exist in their bodies.

CESTODES.—The liquid contents of the large, swollen cysts of *Taenia echinococcus*[3] contain a leucomaine, which, if by accident the cyst be ruptured, is taken up by the lymphatics and blood vessels and sets up an urticaria. A similar leucomaine has been extracted from *Cysticercus tenuicollis*,[4] whose parent form normally inhabits the dog and wolf, though a somewhat doubtful case is recorded of its being found in man. This toxin, if injected into rabbits causes anaemia and death, it also sets up peritonitis and urticaria. According to Von Linstow, the Kirghises use the fluid of *Coenurus serialis*, the larval form of *T. serialis*, to poison wolves.

The fluid, which can be extracted by pressure, from the tissues of *Cysticercus pisiformis* of the rabbit, the larvae of the dog's *T. serrata*, is capable of paralyzing and killing frogs if injected into their bodies. In it Vaullegeard[5] finds an alkaloid soluble in alcohol, and, further, a toxin insoluble in alcohol. The same observer attributes certain general ailments, such as anaemia, to the filtration of the toxins through the membranes which surround the liquid. Blanchard, however, regards the amount that escapes under normal circumstances as "une quantité négligeable." Should, however, the cyst be punctured or ruptured serious consequences will follow.

Turning to the adult Cestodes inhabiting the alimentary canal, they have a well-developed excretory system, and must be excreting throughout their life. Most of the excreta probably pass away with

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[1] Arch. Parasit., 1905, x, p. 84.

[2] Boycott, Journal of Pathology and Bacteriology, 1905, x, p. 383.

[3] Blanchard, Traité Zoologie Médicale, Paris 1885-1889, and Debove, C.R.Ac.Sci., cv, 1887, p. 1285.

[4] Mourson & Schlagdenhauffen, Bull. et. Mém. Soc., Méd. Hôpitaux, Paris, 1888 (3), v, p. 113.

[5] Bull. Soc Nord, France, 1901 (5), iv, p. 84.

the dejecta of the host, but some may be absorbed by the mucous membrane of the intestine. Calamida,[1] by extraction, got from *T. cucumerina* and *T. coenurus*, toxins which had a haemolytic action and possessed a chemiotactic attraction on the eosinophile cells. Some of the toxins excreted by the worms seem to have a bactericidal effect. Professor G. André[2] records seventeen cases of Phthisis in which the presence of Taenias, chiefly *T. saginata*, has helped to retard the progress of the disease. More recently Grancher[3] has drawn attention to similar observations, and records three cases of tuberculosis "auxquels le Ténia semble avoir été beaucoup plus utile que nuisible." Picou and Ramond,[4] Jammes and Mandoul[5] have experimentally proved that an extract from the body of *T. saginata* kills many of the bacteria and saprophytes that infest the alimentary canal, and is particularly fatal to the tubercle bacillus. This action, however, must be specific, as typhoid bacilli flourish alongside the *Dibothriocephalus*. It has also been shown by Weinland,[6] and Dastre and Stassano,[7] that Cestodes defend themselves against the digestive activity of the juice in which they live by the secretion of an anti-body similar to that with which the actual wall of the intestine defends itself against the same destructive influence. This body, according to Weinland, is an antitrypsin, while Dastre and Stassano considered it to be an antikinase. Hamill,[8] who has recently investigated the subject, confirms Weinland's results.

The most pronounced evil caused by Cestodes living in the alimentary canal is a form of pernicious anaemia, associated with the presence of *Dibothriocephalus latus*. The most complete treatise on this subject are those of the Finn—Dr. O. Schauman,[9] and of Askanazy,[10] who show that both in the changes which occur in the blood and in the symptoms that ensue the anaemia caused by the Cestode is only distinguishable from pernicious anaemia in that it disappears when the worms are removed. Although other observers have recorded other cases, and it is generally agreed that the anaemia disappears when the Cestodes are expelled, the view that the disease is caused by their presence is combatted by some authorities. These latter point to the

[1] Centralblatt f. Bakt., 1901, xxx, p. 374.

[2] Contribution à l'étude de la contre-fluxion dans la phthisie pulmonaire. De l'utilité du Ténia dans cette maladie, Paris, 1878.

[3] Bull. Médicale, 1897.

[4] C.R. Soc. Biol., 1899, p. 176.

[5] Bull. Soc. Sci., Toulouse, 1894; and C.R. Ac. Sci., 1904, cxxxviii, p. 1734.

[6] Zeitschr. Biol., 1903, xliv, p. 1.

[7] C.R. Soc. Biol., 1903, lv, p. 130, and p. 251; Arch. Inter. Physiol., 1904, i, p. 86.

[8] Journal of Physiology, 1906, xxxiii, p. 479.

[9] Zur Kenntniss der sogenannten Bothriocephalus Anaemie, Berlin, 1894.

[10] Zeit. f. Klin. Med., 1895, xxvii, p. 492.

fact that the disease often occurs where there are no *Dibothriocephali*, and that the presence of these parasites is by no means always associated with anaemia. This argument is, however, far from conclusive. Experiment gives no certain sound. Vlaiev failed to produce anaemia by injecting an extract of *Dibothriocephalus* into pigeons and rabbits. On the other hand, Schauman and Tallquist,[1] by the same means, induced a state of profound anaemia in a dog, but failed with a rabbit. Blanchard is inclined to the view, and in this he has the support of Shapiro, Viltshur, and Ehrlich, that it is only when the Cestode is ill or dead that a toxin capable of producing the anaemia is given off. Numerous other cases are quoted by Blanchard, which illustrate the injurious and often fatal effects caused by the injection of extracts taken from many species of Cestodes. There seems no doubt that the tissues of these parasites harbour toxins of great virulence. This is admitted on all sides. The question for us, however, is whether these toxins normally leave the body of the parasite and act upon the body of the host. There is no doubt that in a large percentage of cases Cestodes in the alimentary canal have little or no effect on the health of the host. The effect, when an effect is present, may possibly be regarded as a factor of absorption conditioned by the state of the alimentary canal of the host, which may, under certain circumstances, such as fatigue or a change in the intestinal flora, absorb toxins, which under a different set of conditions it ignores. Jammes and Mandoul state that even in children, who seem much more susceptible than adults to the disorders caused by parasites, only 2 per cent. of the infected suffer, and they attribute such symptoms as arise to the mechanical action of the Cestodes rather than to any toxic action.

TREMATODES.—It is difficult to see how the anaemia, ascites, and oedema, which are the characteristic features of sheep-rot, caused by *Fasciola hepatica*, can arise from the mere mechanical presence of the fluke in the bile duct. On the other hand, cases are recorded when the same parasite living in man gave rise to "no particular symptoms," and the same is true of *Fasciolopsis buskii*. *Opisthorchis sinensis*, however, produces many nervous symptoms, which may well be attributed to a toxin given off by the fluke. Such symptoms are morbid hunger and epigastric weighing down. The presence of the *Paragonimus westermani*, and its habit of burrowing in the tissues of the lungs is perhaps sufficient to account for the symptoms which the host exhibits.

Blanchard considers the anaemia, which is perhaps the most pronounced effect of the presence of *F. hepatica* and of *O. sinensis*, is caused by the loss of blood. For though these flukes live bathed in

[1] Deutsche Med. Woch., 1898, xxiv, p. 312.

bile, they really nourish themselves on the blood which they suck from the small capillaries of the biliary channels. The loss, however, cannot be great.

Apparently little actual experiment has been made with the view of extracting toxins from Trematodes. The evidence is less complete here than it is amongst the Cestodes and Nematodes. The question is, to a great extent, one of degree. Blanchard apparently admits that they, like the Cestodes and Nematodes that live in the intestine and bile ducts, do give off some poisons, but he holds that "les substances toxiques qu'ils rejettent" are rapidly eliminated by the alimentary canal, and are only absorbed by the host in quantities too minute to do any harm.

NEMATODES.—The evidence that Nematodes contain and excrete into the body of the host toxins in sufficient quantities to materially affect the host is more abundant and more conclusive than is the case with Cestodes and Trematodes. It is true that their bodies are surrounded by a thick chitinous cuticle, which serves to protect them from the action of certain chemical agents, and which renders them resistant to the attack of phagocytes, so that even when dead they are not always absorbed, *e.g.*, in the case of *Trichinella spiralis* they remain in the organ they infest entrenched in a calcareous coffin. This thick cuticle, which seems so effective an armour in keeping enemies out, might be thought to be equally effective in keeping the toxins in, but we shall see later that the Nematodes produce effects which can hardly be explained on any other theory than that they do give off toxins.

Of the existence of these poisons there is no doubt. A few weeks ago a butcher in Sheffield suffered from severe inflammation of the eye caused by some of the body cavity fluid from an *Ascaris megalocephala* having come in contact with his cornea. The best described case is, however, perhaps that of Dr. H. Charlton Bastian,[1] which we have ventured to quote in full:—

> "Before dismissing the subject of the glandular and secretory organs of these animals, this seems a suitable place for me to record some of the remarkable effects invariably produced upon myself whilst working at the anatomy of *Ascaris megalocephala* from the horse. Emanations from this animal had the most decided and poisonous influence upon me, and this not only when the animal was in the fresh state, but after it had been preserved in methylated spirit for two years, and even then macerated in a solution of chloride of lime for several hours before it was submitted to examination. I first examined this species in the spring of 1863, when certain strange effects were produced which

[1] Phil. Trans, 1866. p. 583. Note.

I was enabled to trace absolutely to the fact of my working with this animal. These were a greatly increased secretion from the Schneiderian membrane, with irritation of it, causing continuous sneezing, also irritation of the conjunctiva, with such a sense of itching about the eyelids and caruncula lachrymalis as to make it extremely difficult to abstain from rubbing them. When they were rubbed this immediately gave rise to a swollen and puffed condition of the eyelids, swelling of the caruncula, and extreme vascular injection of the conjunctiva, and if the rubbing was at all persisted in, actual effusion of fluid would take place under the conjunctiva, raising it from the subjacent sclerotic and cornea. A few minutes would suffice to produce these serious effects upon the eyes, but after a little bathing with cold water, and rest in the recumbent position for a couple of hours, they would have again resumed their natural condition. At the same time that these effects were produced upon the mucous membranes, the skin of the face and neck was also affected, so as to cause a sensation of itching somewhat similar to what exists in a mild attack of nettle-rash. If I continued to work for about two hours in spite of these symptoms, a general feeling of lassitude and weariness was produced, sometimes amounting to an actual sense of prostration, which would, however, all pass off on desisting from the work and lying down for a few hours. After a few weeks another symptom was superadded, in the form of an asthmatic difficulty of breathing, owing apparently to a constriction of the trachea and of the larger bronchial tubes, which was first noticed about one o'clock one night shortly after going to bed. Without any warning I felt a kind of constriction of the upper air-passages, with great difficulty of breathing, each inspiration and expiration being accompanied by an almost musical wheezing sound. This lasted for about three quarters of an hour, when there came a gradual relaxation of the spasm, and all was well again. Such attacks as these gradually became more frequent, generally occurring in the night or evening, lasting longer, and often associated with a spasmodic cough, so that, much against my inclination, I was at last compelled to abstain from any further examination of these noxious individuals. My system at length became so sensitive to the emanations of this animal that I was even unable to wear a coat which I had generally worn during these investigations, without continual sneezing and suffering from other catarrhal symptoms. Avoiding this and other sources of irritation, after a period of about two months every vestige of these symptoms had disappeared, and continued absent till May, 1864. During this interval I had never looked at a specimen of *A. megalocephala*,

neither did I once experience any of the old asthmatic difficulty of breathing. For one day in the beginning of May I did work with this animal again; not so much sneezing and actual irritation was produced at the time, and I was full of hope, but in the evening came one of the old asthmatic attacks, and the influence produced by this one day's work did not completely exhaust itself till the middle of June—a period of nearly six weeks. During all this intervening time I had been subject to occasional spasms and difficulty of breathing. Subsequent isolated periods of work with this Nematoid have also shown me that it takes from one month to six weeks for its effects to entirely disappear. In the spring of this year I again worked daily with these animals for nearly a month, till the symptoms became so severe as absolutely to compel me to desist. A certain change had come over their influence upon me. I now suffered far less from the more local irritating effects, and much more from the severity of the asthma and spasmodic cough. There was a curious kind of periodicity too about the worst attacks; they generally occurred between five and six o'clock in the morning, and so regularly was this the case that it was almost needless for me to look at my watch, on awaking, to ascertain the hour. These attacks would sometimes last for more than two hours, accompanied by extreme dyspnoea, and the most distressing paroxysms of cough. Then at last came a gradual relaxation of the spasm, accompanied by a secretion of thin mucus from the bronchial tubes, followed by an absence of cough and natural breathing for twelve or even twenty-four hours. Not having anatomized these animals since, I have again been entirely free from such symptoms for nearly two months. No effects of this kind were produced by working with *A. lumbricoides;* neither does *A. megalocephala* appear to have affected Dr. Schneider or other anatomists in the manner I have just been stating."

Miram was attacked in a similar way whilst studying the same animal, and Von Linstow, as noted by Nuttall,[1] records that these worms give off a peppery odour, which causes the tears to flow.

Toxins have indeed been prepared from the tissues of *Ascaris megalocephala.* By compressing them, Vaullegeard produced a yellow fluid, 2 c.c. of which, when injected into a guinea-pig, killed it within forty hours, of congestion of the lungs. Larger doses produced vomiting and exhaustion in a dog, but were not fatal. By precipitating, washing and filtering the same observer isolated two toxins, one soluble in water, but not in alcohol, which acts on the nervous system, the

[1] American Naturalist, 1899, xxxiii, p. 247.

other soluble in both, but insoluble in ether, acts to some extent like curari. The former may be the cause of the varying nervous symptoms which sometimes, but by no means always, accompany the presence of Nematodes in the human body; Vaullegeard at any rate adopts this view, but Blanchard is not convinced. Cattaneo[1] observed the same result from *Ascaris lumbricoides*. Blanchard points out that Guiart has described certain erosions of the mucous membrane in a dolphin caused by *As. conocephala*, by which the worm came into contact with the nervous plexus and irritated it. He also favours the view that the typhoid-like symptoms which often arise when the Ascarids are present in the small intestine are probably caused by bacteria, whose passage into the walls of the alimentary canal is facilitated by the punctures caused by some Nematodes, such as *Trichocephalus trichiurus*.

Blanchard also dwells on the fact that Cao[2] and Jammes[3] and others, who seem to have experimented with very great care, failed to obtain any toxic or haemolytic effect with the extracts they prepared. It is evident that we require more investigation before the divergent views of the recent workers can be reconciled.

With regard to Ankylostomiasis, that most debilitating and often fatal disease common in miners and in all who come in contact with the earth, more especially in hot climates, there are two views. One, held by both Blanchard and Vaullegeard, is that anaemia, which is one of the most pronounced features of Ankylostomiasis, is caused by the *Ankylostomas* eating the blood, and also causing haemorrhages into the intestine. The other view is that the *Ankylostomas* give off a toxin which acts haemolytically. But Looss[4] has lately shown that the proper food of the Tunnel-worm is not blood, but the mucous cells lining the intestines. He says, "where dissection speedily follows death, and where the worms are still attached to the intestinal wall and living, many are often to be found not containing any blood," and again, "*blood is not the normal food of the Ankylostoma*." In fact, "*the parasites feed on the mucous membrane of the host*, blood is only sucked in when the parasite accidentally pierces a blood vessel." Looss, who clearly takes the view, as do Boycott[5] and Oliver,[6] that a toxin is produced, and even suggests as its seat of origin the cephalic glands, which in *Ankylostoma* are unusually large, also points out that in certain cases of people who have died of severe anaemia the

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[1] Associazione Medicochirurgia de Parma. Mars, 1903; Abstract in Arch. italiennes de Biologie, 1904, xlii, p. 496.

[2] Riforma Medica, 1901, iv, p. 795; Abstract in Arch. ital. de Biol., 1902, xxxviii, p. 491.

[3] Asso. Franc. p l'Avancement d. Sciences, 1902, xxxi, p. 241.

[4] Reports of the Egyptian Government School of Medicine, 1905, iii.

[5] Boycott, *loc. cit.*

[6] Oliver, Lancet, April 1, 1905, p. 859.

number of *Ankylostomas* found in the intestine was so few that even if they had all sucked blood, the depletion could not possibly suffice to explain the severity of the illness.

Blanchard gives a less certain sound in connection with *Ankylostoma* than he does with other Helminths. He even admits that the cephalic glands give off an active substance which the mucous membrane may be capable of absorbing, but he says this is only an hypothesis. It is evident that under normal conditions he strongly doubts if Nematodes, or indeed any Helminth, gives off any toxin in sufficient quantity to appreciably poison their host.

There is, however, an occurrence which seems to us to argue very strongly in favour of the toxin theory, and that is the remarkable effect the presence of internal parasites have on the number of the eosinophile corpuscles of the blood. Even when the parasites are not necessarily in the blood, as in the case of *Trichinella spiralis*, they seem to exert a force acting at a distance, and to profoundly affect the corpuscles floating in the blood. The investigations into this subject are of comparatively recent origin, and this, coupled with the fact that their results lend so strong a support to the toxin theory, has determined us to devote the remainder of this article to their consideration.

EOSINOPHILIA. The first observations on the occurrence of changes in the relative proportions of the leucocytes of the blood in cases of Helminthiasis we owe to Müller and Rieder.[1] These observers, who studied the blood of patients suffering from a variety of diseases, found in two men infected with *Ankylostoma duodenale* an increase, both relative and absolute, in the number of the coarsely granular oxyphile cells, the eosinophile cells of Ehrlich, and most following writers. Shortly afterwards Zappert[2] reported that he also had found, in two cases of the same disease, a considerable increase of these cells, reaching 17 %; at the same time he demonstrated Charcot-Leyden crystals in the faeces. In a third case, however, Zappert found no increase of these cells, nor could he find the crystals in the faeces. Siege,[3] almost simultaneously, made similar observations.

Bücklers,[4] working under Leichtenstern, directed his attention to the examination of the blood in a variety of parasitic infections, and established the fact that, in its relation to the eosinophile cells, *Ankylostomiasis* does not occupy a special place in diseases caused by worms. All kinds of Helminths, from the harmless *Oxyuris* to the pernicious *Ankylostoma*, may bring about an increase of the

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[1] Deutsch Arch. f. Klin. Med., 1891, xlviii, p. 96.

[2] Wien. Klin. Wochenschr., 1892, v, p. 44; Zeitschr. f. Klin. Med., 1893, xxiii, p. 227.

[3] Quoted by Ehrlich and Lazarus, Histology of the Blood, Eng. trans. by Myers, Cambridge, 1900, p. 151.

[4] Münch. Med. Wochenschr., 1894, xli, p. 21.

eosinophile cells in the blood, often to an enormous extent. Leichtenstern observed that, associated with this increase in the eosinophile cells, he was always able to find Charcot-Leyden crystals in the faeces, an association which has been shown by later observers[1] to be a constant one.

CESTODA.—*Taenia solium and T. saginata.*—These worms commonly cause but little change in the blood; at least, changes are not usually to be found, when patients, suffering from their presence, present themselves for treatment. This, however, may be because, though the eosinophile cells of the blood are after infection at first increased, yet in cases of chronicity this increase may disappear, even though the worm is not removed; a sequence of events which Boycott and Haldane[2] have shown to occur in cases of Ankylostomiasis. Pröscher[3] prepared toxic extracts from both *T. solium and T saginata*, which on injection into the peritoneal cavity of the rabbit and guinea-pig produced a typical eosinophilia (50 %) in the peritoneal fluid. Positive results have been obtained by Bücklers,[4] who records 10.25 % eosinophiles, by Leichtenstern[5] (34 %), and by Boycott[6] (13 %), in cases of infection with *T. saginata;* and by Achard and Loeper[7] (11 %) in infections with *T. solium.* Limasset,[8] who carefully studied 16 cases of tapeworm infection, found that 5 of these at some period showed more than 5 % eosinophiles, and 2 at some period showed more than 10 %, whilst in a single case the eosinophiles reached 26 %. Boycott also reports two cases showing 6 % and 7.2 % respectively. Launois and Weil[9] record 5 % eosinophiles during the whole period of infection.

The eosinophile cells in normal blood form between 1 and 4 % (25 to 500 per cb. mm.) of the total leucocytes; any increase above the latter figure is termed an eosinophilia.

Dibothriocephalus latus acts much more upon the coloured cellular constituents of the blood than upon the leucocytes. The anaemia which it sometimes causes has been carefully studied by Schauman,[10] Askanazy,[11] da Costa,[12] and others. This anaemia is characterised by marked

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[1] Ehrlich and Lazarus, *loc. cit.*; see also Bezançon et Labbé. Arch. Gén. de Méd., 1902, N S. vii, p. 748

[2] Journal of Hygiene, 1903. iii, p. 95.

[3] Folia Haematologica, 1905. ii, p. 543.

[4] Münch. Med. Wochenschr. 1894. xli, p. 21.

[5] Quoted by Ehrlich and Lazarus, *loc. cit.*

[6] Brit. Med. Journal, Nov. 14, 1903, p. 1267.

[7] Bull. de la Soc. Méd. des Hôpitaux, 1900, xviii, p. 867.

[8] Thèse de Paris, 1901.

[9] La Semaine Médicale, 1902, xxii, p. 378.

[10] *Loc. cit.*

[11] Zeit. f. Klin Med., 1895, xxvii, p. 492.

[12] Amer. Med., 1902, v, p. 571.

oligocythaemia, high colour index, by the presence of nucleated red blood corpuscles, the majority of which conform to the megaloblastic type, of poikilocytes, and of cells, which show polychromatophilic staining. It may in some cases closely simulate primary pernicious anaemia. Ehrlich[1] describes severe *Dibothriocephalus* anaemia as "a pernicious anaemia, with a known and removeable cause." It is only distinguishable from true pernicious anaemia by the fact that after the expulsion of the worm by the administration of the appropriate vermifuges the megaloblastic type of blood and the anaemia rapidly disappear, and the patient makes an uneventful recovery.

The leucocytes, in cases of even severe anaemia, are usually but little altered; and according to Schauman, eosinophilia only exists in a small number of cases.

Echinococcus Cysts.—Hayem[2] first noted that the leucocytes were increased in this infection, while Neusser[2] first stated that the eosinophiles were disproportionately increased. The first actual figures are due to Memmi,[3] who in twelve cases of Hydatid Cyst found eosinophilia varying from 7 to 20 %. Dargein and Tribondeau[4] report a similar case, as do also Achard and Clere[5] (up to 40 % eosinophiles), Achard and Laubry[5] (10 %), Bloch[6] (14.7%), Labbé[7] (4 %), Tuffier and Milian[7] (4 to 8 % of 10,000 to 15,000 leucocytes). Lépine,[8] in a case of Hydatid of the Liver, counted 28,000 leucocytes with 18 % eosinophiles. Seligmann and Dudgeon[9] report a similar case showing 17,000 leucocytes and 57 % eosinophiles– three days after operation these fell to 12 % of 7,000 leucocytes, while one month later the blood showed normal proportions.

Longridge[10] reports a similar case with 7,300 leucocytes, and 5 to 8 % eosinophiles, while Limasset reports a number of cases with almost normal blood proportions.

Sabrazés[11] in seven cases always found an increase in the eosinophile cells, sometimes slight and sometimes large (to 1,584 eosinophiles per cb. mm.); he also found always a great accumulation of the eosinophile cells in the neighbourhood of the cysts.

From these records we see that eosinophilia is the rule in Hydatid

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[1] *Loc. cit.*, p. 65.
[2] Quoted by Cabot. Clinical Examination of the Blood, 5th ed., 1904, p. 337
[3] La Semaine Méd., 1901, xxi, p. 376.
[4] Compt Rend. de la Soc. de Biol., 1901, liii, p. 969.
[5] Quoted by Bezançon and Labbé, Arch. Gén. de Méd., 1902, N.S. vii, p. 749.
[6] Deutsch. Med. Wochenschr., 1903, xxix, p. 511.
[7] La Sem. Méd., 1902, xxii, p. 75.
[8] Compt. Rend. de la Soc de Biol., 1902, liv, p. 285.
[9] Lancet, June 21, 1902, p. 1764.
[10] Lancet, July 5, 1902, p. 44.
[11] Münch. Med. Wochenschr., 1903, l, p. 553.

disease. Two negative cases are, however, on record; one due to Bezançon and Weil,[1] the other to Gouraud.[2]

Memmi records that he was able to reproduce the conditions seen in patients by injecting the contents of Hydatid Cysts into rabbits.

Many cases show normal red corpuscles, and according to da Costa,[3] anaemia, when present, is probably due to other factors.

Cysticercus Cysts.—Eosinophilia may or may not be present in cases of infection with the parasite at this stage in its history. Positive cases are reported by Limasset (10 % eosinophiles), Achard and Loeper[4] 11 %, Boycott[5] 8 %, while negative ones by Marie[6] and others.

TREMATODA.—*Schistosomum haematobium* (*Bilharzia*).—Eosinophilia has recently been reported in this disease also. Coles,[7] who first studied the blood in cases of this disease, found 20 % of eosinophiles, whilst Russell[8] reports 23.8 to 33.6 %, and Manson[9] 12 % in a leucocyte count of 8,200 per cb. mm. Douglas and Hardy[10] studied 50 cases, and found an excess of white cells in all cases, an average of 16.48 % of eosinophiles, with 40 % in one case, and only two showing counts lower than 6 %. These observers note that in most of their cases the mononuclears were also increased in number, averaging 12.5 %, and that despite the absence of Malaria. Similar results have been obtained by Balfour[11] (three cases average 16.8 % eosinophiles), by Boycott[12] (47.6 % in one case, and more than 20 % at some stages in five cases).

With regard to other Trematode infections, no information concerning the constituents of the blood is available.

NEMATODA.—*Ascaris lumbricoides.*—The blood, in the case of patients infected with this worm usually shows but little change from the normal, though in some instances the worm seems to have caused anaemia, and in others eosinophilia.

Solley[13] reports in one case 33 % of eosinophiles, whilst Boycott,[14] in two cases, found 23.8 and 25.6 % respectively of eosinophiles.

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[1] and [2] Ref. Arch. Gén. de Méd., N.S., 1902, vii, p. 749.

[3] Clinical Hematology, 2nd ed., 1905, p. 433.

[4] Bull. de la Soc. Méd. des Hôpitaux, 1900, xvii, p. 867. Quoted by Boycott.

[5] Journal of Hygiene, 1904, iv, p. 437.

[6] Bull. de la Soc. Méd. des Hôpitaux, 1900, xviii, p. 1126. Quoted by Boycott.

[7] Brit. Med. Journal, May 10, 1902, p. 1137.

[8] Lancet, Dec. 6th, 1902, p. 1540.

[9] Brit. Med. Journal, Dec. 20, 1902, p. 1894.

[10] Lancet, Oct. 10, 1903, p. 1009.

[11] Lancet, Dec. 12, 1903, p. 1649.

[12] B.M.J., Nov. 14, 1903, p. 1267.

[13] Presby. Hosp. Reports, 1900, v, p. 188.

[14] Journal of Hygiene, 1904, iv, p. 437.

Bücklers[1] records 19 % in one case, and Bezançon and Labbé[2] 6 % in another. On the other hand, Bücklers, Boycott and Limasset[3] all report cases showing no marked increase of these cells. Longridge,[4] in a case of tubercular peritonitis with *Ascaris lumbricoides*, records red blood corpuscles 4,800,000 per cb. mm., white corpuscles 12,400, with 6.8 % of eosinophiles.

The report of the Jenner Hospital at Berne[5] (1890) includes the account of a case in which *As. lumbricoides* was present in large numbers. The blood showed, before the expulsion of the worm by Santonin, but 2,480,000 red cells, while two weeks afterwards the red cells had risen to 4,200,000 per cb. mm.

Oxyuris vermicularis.—This Nematode is not considered to be a factor of anaemia, yet it may cause a well-marked increase in eosinophile cells of the blood. Bücklers,[6] who, however, according to Boycott,[7] was probably dealing with a case of mixed infection, records a count of 19 % eosinophiles. Limasset,[8] on the other hand, had four negative cases. In 19 cases Boycott[7] found that the eosinophiles varied from 0.4 to 13.7 %, with an average of 5.8 %, and states that in about two-fifths of his cases, in children, who harboured *Oxyuris*, a definite increase in the eosinophiles had occurred.

Trichinella spiralis.—The constitution of the blood in cases of patients suffering from Trichinelliasis has received a considerable amount of attention since T. R. Brown,[9] in 1897, first drew attention to this subject. In the blood of a patient, in whose muscles Brown subsequently demonstrated *Trichinellae* on admission to the hospital, the eosinophile cells constituted 37 % of the total number of leucocytes. The proportion was somewhat diminished for a time, but subsequently rose, and on the fiftieth day after admission reached 68.2 %. The total number of leucocytes during the greater part of the illness varied from 15,000 to 30,000 per cb. mm.

Later observers have fully confirmed the results obtained by Brown in this, his first case. Brown[10] afterwards placed three other cases on record, in which 42.8, 45, and 48 % respectively of eosinophiles were found at some stage in the disease.

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[1] Münch. Med. Wochenschr., 1894, xli, p 21.
[2] Arch. Gén de Méd. N.S., 1902, vii, p 748.
[3] Thèse de Paris, 1901.
[4] Brit. Med. Journ., Nov. 8, 1902, p. 1511.
[5] Quoted by Cabot, Clinical Examination of the Blood, 1904, 5th ed , p 503.
[6] Münch. Med. Wochenschr., 1894, xli, p. 21.
[7] Brit. Med. Journal, Nov. 14, 1903, p. 1267.
[8] Thèse de Paris, 1901.
[9] John's Hopkins Hospital Bull., April, 1897, viii p. 79
[10] Journal of Expt. Med., 1898, iii, p. 315; Boston Med. and Surg. Journ., 1898, cxxxix, p. 218; Medical News, 1899, lxxiv, p. 12.

Trichinelliasis.—The results of some later observers are tabulated below.

Name of Reporter.	Number of Cases.	Total Number of Leucocytes per cb. mm.	Percentage of Eosinophiles recorded.
Brown	4	7,900—35,000	8—68·2 %
Gwyn (1)	1	17,000	33—65·9 %
Cabot (2)	4	1,410—25,000	7—37 %
Howard (3)	1	——	normal
Atkinson (4)	1	28,000	35—58·5 %
Stump (5)	1	——	52 %
Lambert and Brooks (6)	1	——	markedly increased
Blumer and Neuman (7)	9	6,000—24,000	8·0—50·4 %
Harlow Brooks (8)	1	18,100	10—84 %
Lartigan (8)	—	——	max. of 68 % noted
Gordinier (9)	2	——	31·9—77·3 %
Kerr (10)	2	10,000—25,000	18·1—86·6 %
Patek (11)	1	——	30 %
Sears (12)	1	9,800—16,200	17·5—30 %
Vickery (13)	2	——	max. 37 %, average 22·3 %
McCrae (14)	1 complicated, with typhoid	11,000—21,700 average 13,740	23·4—15·8 %
Gould (15)	1	9,800	23·7—30·6 %
Cheney (16)	1	12,200—15,000	10·17 %
Drake (17)	4	——	0·6 %
Kinnicutt (18)	1	——	max. 77 %
Schleip (19)	57	5,300—22,600	1·2—62·2 %
Williams (20)	1	9,375	eosinophiles normal percentage

(1) Centralblatt f. Bakt., 1899, xxv, p. 746.
(2) Clinical Examination of the Blood, 5th ed., 1904, Boston Med. and Surg. Journ., 1897, cxxxvii, p. 676.
(3) Phil. Med. Journ., 1899, iv, p. 1085.
(4) Phil. Med. Journ., 1899, iii, p. 1243.
(5) Phil. Med. Journ., 1899, iii, p. 1318.
(6) Trans. N.Y. Path. Soc., 1900, p. 167.
(7) Amer. Journ. of Med. Sci., 1900, cxix, p. 14.
(8) Med. Record, 1900, lvii, p. 885.
(9) Med. News, 1900, lxxvii, p 965.
(10) Phil. Med. Journ., 1900, vi, p. 346.
(11) Amer. Med., 1901, i, p. 513.
(12) Boston Med. and Surg. Journ., 1901, cxliv, p. 523.
(13) Ibidem, May 1901, cxliv, p. 522.
(14) Amer. Journ. of Med. Sci., 1902, cxxiv, p. 56.
(15) Amer. Med., 1903, vi, p. 515
(16) Amer. Med., 1903, vi, p. 985.
(17) Jour. of Med. Research, 1902, viii, p. 255.
(18) Pract. Soc., 1900, lvii, p. 478.
(19) Deutsch. Arch. f. Klin. Med., 1905, lxxx, p. 1.
(20) Journ. of Med. Research, 1901, vi, N.S. 1, p. 64.

From the results shown in the above table, we see that eosinophilia is the rule. Cases showing no eosinophilia are recorded by da Costa,[1] Howard, Drake, and Schleip. According to Schleip, who studied an epidemic at Homberg involving 57 persons, leucocytosis is not a constant feature of this disease, being only found in severe cases, yet the severity of the leucocytosis may be taken as a sure indicator of the severity of the disease.

Schleip found that, on the whole, the eosinophiles did not rise so high in mild cases as in severe cases, yet one severe case showed only 3.2 to 5.9 % eosinophiles of 5,800 leucocytes per cb. mm. He observed that the increase of eosinophiles occurred very shortly after infection—in one case an eosinophilia of 40 to 50 % was reached in ten days after

[1] Clinical Haematology, 1905, 2nd ed., p. 536. Da Costa and Dorsett, Amer. Jour. Med. Sci., 1901, cxxii, p. 725.

infection, that is, before the embryos had begun to enter the tissues—and lasts as long as parasites still remain in the intestine, and until all the embryos have become completely encapsuled in the muscles.

Cabot[1] found that in one of his cases the symptoms entirely disappeared, and the eosinophiles gradually returned to normal. Two years later a recrudescence of the disease occurred, and the eosinophiles became increased as before, later decreasing again as the patient recovered from this recrudescence of the disease.

No changes in the coloured constituents of the blood are recorded as due to this disease, but, according to Schleip, the blood platelets are largely increased in numbers.

Opie[2] fed guinea-pigs on trichinellous pork, and found that the administration of *Trichinella spiralis* caused an increase in the eosinophile leucocytes in the blood, comparable to that which accompanies human infection. This increase usually began at the end of the second week after infection, when their relative and absolute number rapidly increase, and reach a maximum at the end of the third week, "when embryos are in process of transmission from the intestinal mucosa by way of the lymphatic vessels and the blood through the lungs to the muscular system." The increase of eosinophile cells is accompanied by an increased activity of the bone marrow which is the source of these cells. Before death Opie found that the eosinophile cells of the blood always diminished in number. He also found that infection with a large number of *Trichinellae* caused a rapid diminution of the number of eosinophile leucocytes, and is quickly fatal.

This work has recently been confirmed by Stäubli.[3]

Drake[4] studied fifteen cases of Trichinelliasis in swine, but was unable to find any eosinophilia associated with the disease.

In cases of human Trichinelliasis, Ehrhardt[5] always found an accumulation of the eosinophile cells around the encapsuled *Trichinellae;* Opie, in his guinea-pig experiments, found that this did not occur in these animals.

Filaria bancrofti (*Microfilaria nocturna*).—Eosinophilia is a constant feature of recently acquired cases, and occurs, to a less extent, in chronic cases. It is usually more marked when the microfilaria are fewest in the peripheral blood, and decreases as the microfilaria increase there. The red blood corpuscles, and their haemoglobin content, in uncomplicated cases, show but little alteration from normal.

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[1] Clinical Examination of the Blood, 1904, 5th ed., p. 502.

[2] Amer. Jour. of Med. Sci., 1904, cxxvi, p. 477.

[3] Munch. Med. Wochenschr., 1905, lii, p. 971.

[4] Journal of Med. Research, 1902, viii, N.S. iii, p. 250.

[5] Ziegler's Beiträge, 1896, xx, p. 43.

Da Costa[1] records 3.4, 9.5, and 4.3 % respectively of eosinophiles, in three cases of Filariasis with normal leucocyte count. Coles[2] found 15 and 17 % in two cases. Calvert[3] first observed that the development of the eosinophilia followed a cyclical course, following the periodicity of the embryo worms in the peripheral blood—in one case with a leucocytosis of 23,000 per cb. mm., the percentage of the eosinophiles during the course of twenty-four hours varied from 8 to 22, whilst in a second case, in which 10,000 leucocytes per cb. mm. were present, the eosinophiles varied from 3 to 15 %. Gulland[4] records a similar case, in which the eosinophiles varied in the course of twenty-four hours from 3.0 to 12.0 %. Vaquez and Clerc,[5] Sicard and Blais[6] also report cases with eosinophilia varying from 7.5 to 12 %, whilst Remlinger[7] records 70 % in a case of the same disease.

Filaria loa (Microfilaria diurna).—Wurtz and Clerc[8] found in a case of this infection 53 % eosinophiles in the blood.

Filaria medinensis.—A similar eosinophilic increase develops in this disease. Balfour[9] records six cases with eosinophile percentages varying from 6.4 to 36.6 (average 19.6). Powell[10] found in six cases percentages varying from 4.7 to 12.2 (average 7.6), whilst Dudgeon and Child[11] in one case found 18.4 % eosinophiles with a normal leucocyte count.

Trichocephalus trichiurus (Trichocephalus dispar.)—Ostrovsky[12] has recorded a fatal case of progressive anaemia, apparently due to the presence of this worm in the intestine. Becker[13] also reports two cases of anaemia due to this parasite—the blood showing a fall in the number of the red cells, a fall in specific gravity, and in the colour index of the red cells, marked poikilocytosis, and an appearance of a number of nucleated red corpuscles mainly of the normoblastic type. Sandlar[14] has also recorded a fatal anaemia set up by this Nematode.

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[1] Clinical Hematology, 1905. 2nd ed., p 420.
[2] Brit. Med. Journ, May 10, 1902, p. 1137.
[3] John's Hopkins Hospital Bull., 1902, xiii, pp. 23 and 133; Journ. Amer. Med. Assoc., 1902, xxxix, p. 1523.
[4] Brit. Med Journ., April 5, 1902, p. 831; Journal of Trop. Med., 1903, vi, p 277.
[5] Compt. Rend. de la Soc. de Biol., 1902, liv, p. 1425; La Semaine Méd., 1902, xxii, p. 418.
[6] Compt. Rend. de la Soc. de Biol., 1902, liv, p. 1427.
[7] Ibidem, 1902, liv, p. 1145
[8] La Semaine Méd., 1903, xxiii, p. 420; Compt. Rend. de la Soc. de Biol, Dec. 19, 1903, lv.
[9] Lancet, Dec. 12, 1903, p. 1649.
[10] Brit. Med. Jour., Jan. 9, 1904, p. 73.
[11] Journal of Tropical Med, 1903, vi, p. 253.
[12] Abstr. in N.Y. Med. Journ., 1900, lxxii, p. 826.
[13] Deutsch. Med. Wochenschr., 1902, xxviii, p. 468.
[14] Deutsch. Med. Wochenschr., 1905. xxxi, p 95.

P. K. Brown,[1] in twelve cases, in which this parasite was the only one found in the stools, found that the eosinophiles rarely fell below 5 %, and considers that "eosinophilia is a strikingly constant symptom" of these infections.

Becker, and French, and Boycott[2] deny this: the latter observers give 2.1 as the average eosinophile percentage in their cases infected with *Trichocephalus trichiurus.*

Strongyloides intestinalis (*Anguillula stercoralis*).—Bücklers,[3] in a case of pure infection, found 13.5 % eosinophiles, and also an increase in the lymphocytes. In a similar case, P. K. Brown[4] found 9,400 leucocytes per ch. mm., and 6.3 % eosinophiles, but no increase in the non-granular cells. In three cases reported by Thayer[5] eosinophilia was absent, while Price[6] records 10 % eosinophilia in a similar case. Pappenheim,[7] on the other hand, found only 0.8 % of 15,000, and Strong[8] 0.1 to 0.3 % of 36,000 leucocytes in patients infected with this parasite.

None of these cases showed any anaemia or leucocytosis, though Teissier,[9] probably in a case of mixed infection with *Filaria*, records a marked anaemia in this infection.

Ankylostoma duodenale.—This parasite produces changes in both the coloured and colourless constituents of the blood. These changes have recently been very carefully studied by several observers, more especially by Boycott and Haldane[10] in England, and by Ashford in Puerto Rico.[11]

Zappert,[12] in 1892, first stated that this worm was a cause of anaemia, whilst Müller and Rieder,[13] and later Zappert,[14] first called attention to the eosinophilia produced by it—the eosinophilia which later observers have shown to be so constant a symptom of the infection.

Changes in the volume of the Blood.—Boycott and Haldane have

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1 Boston Med. and Surg. Journ, 1903, cxlviii, p. 583.

2 Journal of Hygiene, 1905, v, p. 274.

3 Münch. Med. Wochenschr., 1894, xli, p. 21.

4 Boston Med. and Surg. Jour., 1903, cxlviii, p. 583.

5 Journ. Expt. Med., Nov. 29, 1902, vi.

6 Journ. Amer. Med Assoc., 1903, xli, p. 657.

7 Centralblatt. f. Bakteriol., 1899, xxvi, p. 608.

8 John's Hopkins Hospital Reports, 1902, x, p. 91.

9 Arch. de Méd. Expér. et d'Anat. Path., 1896, viii, p. 586; Compt. Rend. de l'Acad. des Sciences, 1895, cxxi, p. 171.

10 Journal of Hygiene, 1903, iii, p. 95; and Boycott, Journal of Hygiene, 1904, iv, p. 437.

11 N.Y. Med. Journal, April 14, 1900, lxxi, p. 552; American Med., 1903, vi, p. 391; see also Cabot Clinical Examination of the Blood, 5th ed., 1904, p. 495; and Stiles. Hookworm Disease. Bull. x, Hyg. Lab. U.S. Pub. Health Service, Washington, Feb., 1903, p. 70.

12 Wien. Klin. Wochenschr., 1892, v, p. 347.

13 Deutsch. Arch. f. Klin. Med., 1891, xlviii, p. 96.

14 Zeitsch. f. Klin. Med., 1893, xxiii, p. 227.

shown that, as in ordinary Chlorosis, the total volume of the blood is much increased, whilst the total oxygen capacity is slightly diminished. The average increase in volume was 94 %, the average decrease in oxygen capacity 11 %.

Changes in the Constituents of the Blood. (*a*) *The Coloured Constituents.*—Blickhahn [1] in 1893 reported a case of anaemia showing only 800,000 red cells per cb. mm., due to the presence of this Nematode. Rogers [2] reports, as an average of twelve cases, haemoglobin 15 % red cells, 2,145,000 per cb. mm., colour index 0.35.

Sandwith [3] reports as averages of one hundred and seventy-three Egyptian cases, red cells 1,290,000 per cb. mm. (with a minimum count of 930,000); haemoglobin 26 % (from 10 to 54 %). The leucocytes, on admission to the hospital, averaged 10,360 per cb. mm., while on discharge they averaged 15,730 per cb. mm.

Ashford [4] records haemoglobin average 21 %, red cells 1,776,000, thirteen out of one hundred and twenty-seven cases studied showed counts below 1,000,000, colour index always low, leucocytes 7,000, and gives, as characteristics of the condition, "(1) severe anaemia, (2) very low haemoglobin averages, (3) very low colour index, (4) frequent presence of normohlasts, and in some cases of megaloblasts, but never a majority of megaloblasts, (5) Poikilocytosis common."

The epidemic studied by Boycott and Haldane was a comparatively mild one. In thirty-three anaemic cases reported on by these observers, their counts varied from 1,500,000 to 5,400,000. The colour index in all but four cases was low. Poikilocytosis and polychromatophilia were found in a few cases, as were also normoblasts.

Similar results were obtained by Claytor,[5] Schaeffer,[6] Hall,[7] Greene,[8] Smith,[9] Capps,[10] Evans,[11] Grawitz[12], Guiteras[13], Ferrier,[14] Allyn, and Behrend,[15] Herrick,[16] Yates,[17] and others.

[1] Med. News, 1893, lxiii, p. 662.
[2] Journ. Path and Bact, 1898, v, p. 399; Brit. Med. Journ., 1900, ii, p. 544.
[3] Lancet, June 2, 1894, p. 1362.
[4] N.Y. Med. Journ., 1900, lxxi, p. 552.
[5] Phil. Med. Journ., 1901, vii, p. 1251.
[6] Med. News, 1901, lxxix, p. 655.
[7] Journ. Amer. Med. Assoc, 1901, xxxvii, p. 1464.
[8] N Y. Med. Journ, 1902, lxxv, p. 460.
[9] J.A.M.A., 1903, xli, p. 712.
[10] J.A M.A., 1903, xl, p. 28.
[11] J.A M A., 1903, xl, p. 990.
[12] Deutsch. Med. Wochenschr., 1901, xxvii, p. 908.
[13] Amer. Med., 1902, iv, p. 100.
[14] Arch. de Parasit., 1905, x, p. 77.
[15] Amer. Med., 1901, ii, p. 63.
[16] Amer. Med., 1902, iv, p. 101.
[17] John's Hopkins Hospital Bull, 1901, xii, p. 366, where other cases are quoted.

(*b*) *The Leucocytes.*—In Boycott and Haldane's cases the range was from 3,800 to 56,000 per cb. mm., with an average in sixteen anaemic cases of 13,000. The highest counts (56,000, 44,000, 24,000, and 20,000) were all found in cases of recent infections, and were not associated with severe symptoms. The lowest counts were in cases of from two to four years standing. In Rogers' cases, and in all but one of Ashford's cases, presumably more chronic, the leucocytes were normal or sub-normal. Of other observers, some have found leucocytosis, while others have failed to do so. Sandwith found, contrary to the general rule, that the number of leucocytes, in his cases, increased as the patients became convalescent.

Differential Count.—All observers are agreed that the main feature of the blood in these cases is the presence of an eosinophilia both absolute and relative. According to Boycott and Haldane, the eosinophilia varies with the total leucocyte count, and is "most constant and best marked in those who are not suffering from anaemia, that is, in those persons who show nothing which would suggest that they harbour the worm."

The eosinophilia may be moderate, or it may be enormous. Leichtenstern[1] records 72 %; the highest figures given by Ashford are 40 % of 18,000, and 53.5 %; while the highest given by Boycott and Haldane are two cases of 66 % of 56,000 and 44,000 respectively.

Ashford[2] agrees in the main with Boycott and Haldane's results; he finds the highest percentages in recent cases, and the lowest in chronic cases, and states further that, "after treatment in chronic cases and those in the later stages of the disease a rise in eosinophiles is to be expected, and is of good prognostic import; when, however, there is a fall in eosinophiles and no improvement in physical signs, death may often be the result," and, moreover, urges that "the presence of a high percentage of eosinophiles is a favourable prognostic sign, whilst it is an unfavourable one if the percentage is low or absent."

The records, which we have briefly summarized, of the effect produced by various parasites lodged in various parts of the body on the cells of the blood, seem to us to conclusively prove that these metazoan parasites do give off toxins which profoundly affect the tissues of their host. In the first half of our article we have recorded numerous observations supporting the same view; these observations are not in all cases quite conclusive, but the fact of the association of a marked eosinophilia with the presence of parasites in the body does seem to us a conclusive proof that toxins are given off in considerable quantities by all the better known human entozoa.

We are however only at the beginning of the matter. Apparently

[1] Quoted by Ehrlich and Lazarus, *loc. cit.*, p. 151.
[2] Ashford and King, Amer. Med., 1903, vi, p. 391.

there is little or no difficulty in persuading observers to make blood-counts, but the further and far more arduous work of attacking the problem from the chemical side has, as yet, found few investigators. It indeed requires men of special training, but until it is done the problems raised above will remain unsolved.

Cambridge,
March, 1906.

THE BIONOMICS OF GRAIN WEEVILS.

By

F. J. COLE, B.Sc. (Oxon.).

THIS work, of which the present paper is a short abstract, was undertaken originally at the instance of a firm of underwriters in Liverpool, but was subsequently continued on account of some of the interesting results obtained. The insects used were the well-known corn and rice weevils (*Calandra* (*Sitophilus*) *granaria* and *oryzae*), which are responsible for such extensive damage to (chiefly) badly ventilated damp cargoes carried by sailing vessels. When it is remembered that an ordinary cargo, say of Californian barley, is valued at £20,000, the importance of a thorough knowledge of the bionomics of grain weevils becomes manifest. My work extended over some eighteen months, and involved a very large number of experiments, so that only a brief summary of the results obtained can be attempted here. These may be classified under the following heads:—

A.—The Influence of Direct Moisture at Various Temperatures.

In all the experiments the vehicle selected to hold the moisture (sawdust or blotting paper) was thoroughly sterilised before using, each grain of barley or wheat was carefully examined with a lens, to be certain that it was free from weevil infection, and active, healthy, copulating weevils were selected, so as to ensure an equality of the sexes. The weevils were confined in small glass crystallising dishes, with a layer of moist or dry blotting paper or sawdust at the bottom, which was covered with a stratum of barley or wheat, and escape prevented by means of a fine gauze secured over the mouth of the dish by an elastic band. This of course allows free communication with the atmosphere of the incubator.

The first incubator used was the one devised by Hearson for hatching fowls' eggs. This of course provides a fairly moist *ventilated* atmosphere. Ten *C. granaria* were selected, and the temperature varied from 78° to 102° F. It was very soon found that the most appropriate temperature was 80° F., and this was firmly established by numerous other experiments. The heat caused the sawdust to dry up, and it was re-moistened every day, often to such an extent that the dish was swim-

ming with water. The weevils fed (sometimes as many as eight feeding on one grain), and often attacked soft rotting and mouldy grains when there were dry ones in the dish, they even at times completely buried themselves in the *damp* sawdust; copulation was frequently observed (but no eggs laid), and at the end of the 49th day all were alive and quite healthy except one, which had died on the fifth day. Many of the grains were completely destroyed except the husks, others had been partially eaten, and most were soft, rotten and mouldy. In another experiment with blotting paper, which dries much quicker than sawdust, and thus prevents the grain from rotting, eight weevils out of ten were alive and healthy at the end of the 44th day, and five grains contained living, feeding grubs of different ages.

Now if the weevils are placed in the same incubator, and at the same temperature, but with *dry* blotting paper or sawdust at the bottom of the dish instead of moist, the results are vastly different. This was done a number of times, but the weevils never survived the fourth day, and were frequently all dead by the second. The withdrawal of the water therefore can be the only explanation of the mortality.

If we omit the damp cloth which provides the moisture in the incubator, *i.e.*, if we use a *dry* atmospheric incubator, the results are practically unaffected. In one experiment with damp sawdust all the weevils were alive and healthy at the 49th day, many of the grains had been destroyed, but none contained grubs, and copulation was only observed once. The influence of temperature was well illustrated on the 16th day, when the gas in the incubator had accidentally gone out, and the temperature had dropped to 55° F. The weevils were found quite torpid, and buried in the damp sawdust. On the preceding and following days, when the temperature was 84° F., they were all most lively. The same result was observed in all the dishes in the incubator at the time. In experiments with dry blotting paper and sawdust none of the weevils survived the third day. Hence a percentage of water vapour in the atmosphere of a *ventilated* incubator has no appreciable effect on the results.

The use of moist blotting paper, which does not rot the grain, and a steady temperature of 80° F., give extremely favourable results as regards the weevils themselves, and further a moderate percentage of eggs are deposited and develop under these conditions. It, however, by no means represents the ideal conditions for *reproduction*, as we shall see. We can, however, apply an excellent test to the above conclusions, as follows: Moist blotting paper, temperature 80° F., dry, ventilated incubator, 10 *C. oryzae*. Feeding commenced on third day and continued throughout. Copulation first observed on 7th day, and noticed at intervals afterwards. On 23rd day all the weevils were alive

and very active, and I ceased moistening the blotting paper. As a result, all the weevils but one had died by the 28th day, thus amply confirming the previous result, that desiccation is very unfavourable to the life of this insect. I may mention here that the rice weevil is distinctly less sensitive to desiccation than the corn weevil, and the former will live twice as long under the same conditions of desiccation as the latter, but it does not feed or reproduce, and the extermination is effected in six or eight days instead of two and four. To both of them cold is very fatal, and owing to a characteristic failure of the laboratory heating apparatus during one frosty night I lost the whole of my large stock of adult beetles. I find also that spraying with ordinary cold tap water is equally fatal.

If the weevils are kept at the ordinary temperature of the laboratory, instead of being put into an incubator, the results are naturally different. In one experiment with ten *C. granaria* on moist sawdust, the temperature varying from 51° to 76° F., the weevils fed slightly, and even copulated, and on the 48th day four were still alive and healthy. In another experiment conducted at the same time but with *dry* sawdust, the weevils did not feed, and all were dead by the 14th day. In a second set, with moist sawdust, and *C. oryzae* (same temperatures), *all* the weevils were alive on the 38th day; they had been feeding slightly, and one grain contained a small dead grub, whilst a control set with dry sawdust did not feed, and were all dead by the 8th day. Numerous repeats showed that *C. oryzae* was more sensitive to lower temperatures than *C. granaria*—a result to be expected, seeing that the former can stand higher temperatures than the latter.

We may therefore conclude so far: (1) that moisture with the appropriate temperature (80° F.) is very favourable to the adult insect; (2) that the same temperature without moisture is very fatal; (3) that even with temperatures much below 80° F. the presence of moisture is capable of materially extending the life prospects of the weevil.

I now tried damping the vehicle with sea water instead of tap water. This does not evaporate so quickly, but it rots the grain so badly that it has to be frequently replaced. Of ten *C. oryzae*, kept at an average temperature of 95° F., seven were still alive on the 23rd day, but were very quiet. Ten more rice weevils, kept at the lower and more favourable temperature of 85° F., were more lively, fed and copulated, but died at once on withdrawal of the sea water. Five of the grains contained living, feeding grubs. In another experiment with sea water, at the temperature of the room (62° to 76° F.), the rice weevils fed slightly, copulation was once observed, and all were alive at the end of the 23rd day, but were quite torpid and buried in the wet sawdust. Sea water, therefore, is not only not fatal to weevils, but may even assist in prolonging their life.

B.—THE INFLUENCE OF INDIRECT MOISTURE OR WATER VAPOUR.

We have seen that the most favourable temperature is 80° F., and, further, that at this temperature the weevil cannot live without moisture *in a ventilated atmosphere*. Now if the moisture is direct the grain is softened and rots, and whilst the adult weevil will still feed and thrive on it, I was quite unable to satisfactorily *breed* weevils with direct moisture, *i.e.*, it is unfavourable to the development of the larva. Further, the ventilation of the incubator and in the room produces desiccation, and therefore makes the renewal of the moisture all the more necessary. I therefore determined to try the effect of water *vapour* in a *non* ventilated atmosphere, *i.e.*, to test the effect of a closed, "stuffy" atmosphere saturated with water vapour. With this object I selected a small museum jar, $3\frac{1}{2} \times 5$ in., with a well-ground, tightly-fitting stopper, and into this was run a small quantity of tap water. The crystallising dish, with the weevils and their food only, and covered by the gauze to prevent their escape, was placed on a small pedestal so as to lift it out of the water, and the stopper of the jar tightly secured. The weevils are hence in an absolutely non-ventilated atmosphere, *of about half a pint*, charged with water vapour, and in some of the experiments the stopper was kept in for weeks at a time, so as to test the weevils as severely as possible by the rarification of the oxygen inside the jar and the accumulation of carbonic acid gas. The results were most striking, and I now give them in the case of three experiments, all conducted under the same conditions.

1. Commenced April 23rd. Ten *C. oryzae*. Food, grains of wheat. Temperature varied from 80° to 91° F.—average, 83° F. On the second day feeding and copulation commenced, and both continued very freely throughout the experiment. On the 30th day three new weevils had appeared, making thirteen in all—all perfectly healthy, and no deaths. On May 29th, there were fifteen weevils, on June 5th, twenty-three, June 27th, seventy-five, whilst by July 13th the wheat swarmed with them. By this time the grain was very mouldy, but had not germinated. When the stopper was removed from the jar the air was very foul.

2. Commenced same day. Ten *C. oryzae*. Temperature, 80° to 99° F.—average, 88° F. Feeding commenced on the third day, and copulation on the fifth, and both continued. No deaths. By the 29th day three new weevils had appeared, making thirteen. On May 29th there were seventeen, June 5th, twenty-four, June 27th, sixty-five, and by July 13th the grain, which was very mouldy, was thick with them.

3. Commenced same day. Same incubator as 2. Ten *C. oryzae*. Feeding commenced third day, and copulation on the 8th, and both continued. One death on 21st day. By May 29th seven new weevils

had appeared, making sixteen. On June 5th there were twenty one, on June 27th, fifty-five, and by July 13th they were swarming, and the grain smelt very sour, rank, and mouldy.

Experiments conducted on these lines give by far the most successful results in breeding grain weevils, and we must therefore accept it as demonstrated that a non-ventilated atmosphere at about 80° F., charged with water vapour (no matter how poor in oxygen, and contaminated with carbonic acid gas), provides the most favourable conditions for the life and reproduction of these weevils. It will be noted above that the first new generation appeared, in all three cases, *in practically the minimum time*. It is quite clear, however, from practical experience that it is not necessary that the air should be *saturated* with water vapour, and, further, experiments showed that a percentage of water vapour sufficient to turn the grain from a pale yellow to a golden yellow, but not to produce mould or appreciable softening, also gives most satisfactory results.

C.—The Effect of Direct and Indirect Moisture on the Developmental Stages.

It is important to realize that any laboratory experiment, necessarily restricted to small quantities, can only give us absolute results. These results are, of course, indisputable, as far as they go, but it is dangerous to argue from them to the purely relative conditions that obtain in a granary and in the hold of a large vessel. Incubators are of limited size, and the desiccation that they produce is, of course, much greater than is possible under commercial conditions. During my last summer in Oxford, Professor Weldon kindly placed at my disposal a much larger incubator than those I had used at Liverpool, and therefore in the following experiments I was able to deal with larger quantities. The material I used was barley, taken from an infected cargo. This barley had been "screened" or sifted under a strong air blast, which removes all the weevils with their excreta, together with the partly-devoured light grains. The resulting barley is to all appearance perfectly sound, is, I am informed, sold as sound grain, but of course is infected with the invisible eggs and larvae, and if the appropriate conditions supervene is soon as bad as ever. I tested a number of gentlemen of experience on the Liverpool Corn Exchange with some grains of wheat which I knew by examination with a lens contained weevil eggs and larvae, and they all declared the grain to be quite free from weevil infection, though defective in colour.

On May 29th, two large glass vessels, each containing a column of "sound" barley, six inches deep and eight inches wide, and *no adult weevils*, were placed in an incubator, and kept at an average tem-

perature of 80° F. One jar (A) was simply covered with gauze, secured by an elastic band, whilst over the gauze of the second jar (B) was placed a damp sponge, and the whole covered by a tightly-fitting glass plate. In A, therefore, the grain would undergo desiccation, whilst in B there would be a non-ventilated atmosphere, plus the water vapour from the damp sponge, which was not allowed to dry. The gauze prevents the weevils getting at the sponge, which they would certainly otherwise do. By July 10th, in jar B, the barley was swarming with *C. oryzae*, which were far too numerous to count. They were feeding voraciously, and the barley had a warm, damp, musty smell. In jar A I counted only 113 weevils, and there were but slight traces of feeding. Whilst these experiments again strikingly emphasize the importance of moisture, it will be noticed the latter is not quite in accord with results of previous experiments under similar conditions of temperature. We are here, however, dealing with a much larger quantity of grain, and the desiccation is therefore correspondingly less severe. It does, nevertheless, suggest the possibility, but not, I think, the probability, that if it were possible to deal experimentally with commercial quantities, the results would be materially different. They would doubtless be modified, but not reversed. It seems also probable that the grub requires less moisture than the perfect insect, and in point of fact the majority of the 113 weevils above represent the first generation (hatched out from eggs already there), which, however, did not itself breed.

A precise duplicate of the above experiments was tried, but at the temperature of the laboratory. This varied from 60° to 82° F., but for the greater part of the time was 60° to 65° F. On July 10th, only eight *C. oryzae* were found in the grain, and two of these were dead. This again exemplifies the importance of temperature. Low temperatures put a very effective stopper on the weevil.

To test direct moisture, a large quantity of "sound" barley was damped sufficiently to cause it to germinate, but not to become rotten, and placed in an incubator at 75° F. on April 14th. Except for an odd specimen here and there, not ten in all, the weevils failed to hatch out, even after four months. This confirms what we have seen already, that direct moisture in the grain is detrimental to the developmental stages.

D.—The Effect of Carbonic Acid Gas.

I have shown that the weevils flourish exceedingly in a non-ventilated atmosphere, and as carbonic acid gas will accumulate in such an atmosphere, being given off both by the weevils themselves and also by the grain, whether germinating or not, it is important to test

the weevils with this gas, which would naturally be given off in greater quantities in an incubator.

Ten rice weevils were placed at 10-37 a.m. in a glass vessel containing a pure atmosphere of thoroughly *dried* CO_2 (*i.e.*, no free oxygen). Temperature, 72° F. In half a minute all were apparently dead. They were taken out at 11-47 a.m., and although seemingly dead, they soon all recovered. Returned to the jar at 12-30, and removed again at 4 p.m. By 4-30 five were crawling about, and the other five were also living, but very quiet. Returned to the jar at 4-35. The next day (temperature, 73° F.) they were removed at 10 a.m., and were all dead.

In another experiment the weevils were placed in an atmosphere of CO_2 and water vapour, but no free oxygen. Ten *C. oryzae* were put in the mixture at 10-50 a.m., and removed at mid-day. All recovered in a short time. Returned at 12-15, and removed again at 4 p.m. By 4-30 several appeared to be coming to, but without waiting any further they were returned at 4-35 p.m. Removed the next day at 10 a.m., when all were apparently quite dead. However, at 11 a.m. two recovered, at 11-30 a third, at 11-45 three more, at 11-50 a seventh, at 12 an eighth, and by 12-45 all had recovered, and were fairly active.

In subsequent experiments I succeeded in keeping weevils alive for several days in a *moist* atmosphere containing 80 per cent. of CO_2. Whilst, therefore, pure dried CO_2 is very fatal, acting, judging from my next series of experiments, either as a *poison*, or as a desiccator, or both, and not merely as an oxygen barrier, a mixture of the same gas with water vapour (still without free oxygen) is appreciably less fatal, thus adding one more testimony to the importance of moisture to these animals. Hence also almost any accumulation of CO_2 in the atmosphere in which the weevils are living may be disregarded as a preventive agent.

E.—The Effect of the Deprivation of Oxygen.

If weevils can flourish in a non-ventilated atmosphere, it is clearly important to ascertain how they behave in vacuo, and to what extent oxygen is necessary to their existence. It was here that I obtained my most remarkable results, as will be seen from the brief records of a few of my experiments below. In these I used a new double-action vacuum pump, fitted with a mercury barometer gauge.

1. Ten *C. oryzae*. No moisture under bell jar. Temperature varied from 67° to 74° F. Mercury of gauge reduced to 5 inches. On the third day three died, on the fourth day six, and by the seventh day all were dead. No feeding.

2. An exact repetition of experiment 1, except that a dish of water, from which all free oxygen in solution had been previously extracted,

was placed under the bell jar with the crystallising dish containing the weevils, in order to provide a moist atmosphere. Temperature varied from 62° to 76° F. Ten *C. oryzae*. Mercury reduced to 5 inches. Feeding commenced on the third day, and there was one death then. On the fifth day three died, and an egg had been laid on one of the grains, but nothing came of it. On the fourteenth day copulation was observed, and on the seventeenth day there was a further death. The experiment was stopped on the 23rd day, when five of the weevils were still alive, and quite healthy and active, and five grains had been more or less eaten.

These two experiments emphasize again the importance of moisture to grain weevils. In the first one it would have been concluded that the weevils died owing to the deprivation of oxygen, but the second experiment proves at once that the deaths were due rather to the severe desiccation which would naturally be set up in the first case.

3. Here the moisture and food were combined in the form of slightly damp bread, of which weevils are very fond, but which is largely forsaken when it dries. Ten *C. oryzae*. *Mercury reduced to one inch!* On the fourth day there were three deaths, on the eleventh day there was another, and a further one on the twelfth day. The experiment was stopped on the fifteenth day, when five of the weevils were still alive, and at once became very active on being removed from the pump.

The fact that five weevils out of ten lived, fed, and even copulated for twenty-three days, at 5 inches of mercury, and that a similar number survived for fifteen days at one inch is highly surprising, and indicates that the weevils, in what is now their state of nature, must often be called upon to live in an atmosphere rare in oxygen, and have thus become acclimatised to such a condition. In the face of these and my other results it would be absurd to hold either that weevils require a free play of air, or even that free access to air, when possible, is favourable to their existence.

Speaking generally, my experiments with grain weevils entirely support what I believe to be the general opinion of the trade with regard to these destructive animals. Much grain is brought to this country after a long voyage in sailing vessels which have to pass twice through the tropics. It seems to be the general experience of marine surveyors that no cargo ever arrives that is *absolutely free* from weevil. It is therefore important that the ravages of the insect should be confined to within as narrow limits as possible. This is done by stowing the grain in sacks, and by thorough ventilation of the cargo. These precautions of course result in keeping down the temperature and in carrying off water vapour, and are certainly the best that could be followed.

Note.—In experimenting with grain weevils, it is important to remember that no animal shams death so successfully, or keeps it up for a longer time than these small insects. Much of my earlier work had to be repeated owing to my failure to realize this. Afterwards I started a mortuary incubator, kept at the most favourable conditions of temperature and moisture, and only concluded that my specimen was dead after giving it plenty of time to recover in this elysium.

Finally, with regard to the vacuum experiments, I am of course aware that it is difficult to evacuate an animal with a complex tracheal apparatus, and that this source of error must be duly considered.

NOTE ON THE DEPOSITION OF THE EGGS AND LARVAE OF OESTRUS OVIS, LINN.

By

WALTER E. COLLINGE, M.Sc.

WHEN describing the life-history of the Sheep Nasal Fly, *Oestrus ovis*, Linn., in my Report on Injurious Insects, for 1904,[1] I stated, "with reference to the deposition of eggs or larvae very divergent accounts have been given by different writers," and I there put forward an explanation, founded upon a lengthy series of observations, showing why both methods should obtain.

The observations there recorded have evidently not been seen by certain writers, and it has been suggested to me that I should place the same on record in some medium wherein they will obtain a wider publicity.

In 1903-4 and 1905, in certain fields at Aston Fields and Bromsgrove, Worcestershire, this fly was exceedingly plentiful, and on dull days there was no difficulty in collecting them from off the fencing around the fields. Knowing that there were many points in the life-history of this species upon which much uncertainty existed, I thought it a convenient opportunity to try and settle some of them, and one of the first I took up was this question of whether the female fly deposited eggs or larvae on the nostrils of the sheep.

Riley states that they only deposit living larvae, whilst other observers state that eggs only are deposited. Mr. Fred V. Theobald, in one of the most recent accounts,[2] states: "I have been fortunate, by chance, to see two of these flies settle on sheep, and in the most lazy way, without causing any annoyance to the future host of their progeny, deposit as many as fifteen eggs around the sheep's nostrils. One cannot mistake these curved ova, and, moreover, the eggs were not quite mature. On two occasions I have seen these characteristic "nits" on the nostrils of sheep. It is not right to say they always deposited young vivipparously. I very much doubt if they do so at all in this country. At least, we have no authentic records of such having been done. On the other hand, we have Riley's statement, and this

[1] Report on the Injurious Insects and other Animals observed in the Midland Counties during 1904.

[2] Journ. S.E. Agric. Coll., Wye, 1903, p. 71.

must carry great weight. That they only deposit young is not right; they may do so, on the other hand."

Dr. MacDougall[1] states: "The pest is worst in the summer and early autumn, when, tempted out by the sunshine, it circles round the sheep, darting in at them, and depositing the maggots within the nostril."

During 1903, four or five cases were met with where eggs only were deposited, and two where only living larvae were. No explanation at the time seemed to be forthcoming. It was not until 1904 that any further light was thrown upon the subject. Being in the neighbourhood of Bromsgrove on a dull day in June, I remembered a promise to collect some of these flies for an entomological friend, but owing to lack of time only three specimens were obtained. These were placed in a tube in 90 per cent. alcohol, and upon examination on my return I was somewhat surprised to find that in two of the specimens there were larvae, the third example was a male. This at once suggested a possible explanation, and by further observation during the summer of 1904-5, I have no doubt in my own mind that it is the correct one.

The eggs are usually deposited two or three days after copulation, and in hot, dry weather the 12 to 18 characteristic curved ova can be found on the sheep's nostrils. So far as my observations go, this is always the case during hot, dry weather. But if a sudden change takes place in the weather, rain or a lower temperature ensuing, the females remain inactive, and may be found on fences, palings, etc. During this period some of the ova develop within the body of the parent, and on the return of bright, hot sunshine she deposits 5 to 7 living larvae on the nostrils of the sheep.

All who are acquainted with the habits of the *Oestridae* know how they love the bright, hot sunshine, even on a hot day avoiding the shade; if, after fertilisation, such climatic conditions prevail for two or three days, eggs are deposited; if cold, damp conditions prevail, and a longer period intervenes, living larvae are deposited.

This explanation may not be the correct one, but it so admirably agrees with my observations made during the past three years, that I think it worth putting forward.

[1] Trans. Highland and Agric. Soc. Scotland, 1899 (s. 5), vol v, p 190.

ON THE LIFE-HISTORIES OF THE OX WARBLE FLIES HYPODERMA BOVIS (DE GEER), AND H. LINEATA (VILLERS).

By

A. D. IMMS, B.Sc. (Lond.),

1851 Exhibition Science Research Scholar, Christ's College, Cambridge.

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THE present paper is an account of the chief facts which are known concerning the life-histories of the Ox Warble Flies *Hypoderma bovis* and *H. lineata*.

I.—INTRODUCTION.

Ox Warble Flies have long been familiar to the stock-raiser and the hide merchant owing to the extent of the ravages which they commit during their larval stages. Little, however, has been done to keep them in check, and this to a large extent owing to the lack of an exact knowledge of their habits and economy.

The family of the *Oestridae*, to which they belong, is one of the greatest economic significance, inasmuch as all its members are parasitic during the larval condition in the tissues of various species of Vertebrata. Although much has been written relating to the *Oestridae*, our knowledge of the group is extremely fragmentary. This is mainly owing to the great difficulties which have to be encountered in studying the life-histories of the various species, and to the fact that the perfect insects themselves are but seldom met with. Exact observations on those species which attack our domestic animals are greatly needed.

Prof. Brauer ('87, p. 4) has classified the *Oestridae* on the com-

bined characters of the larvae and perfect insects. He divides them into:—

A.—*Oestridae Typicae.*

1. *Gastricolae.* Larvae found in the gut and stomach of the Equidae and Rhinocerotidae. Ex. *Gastrophilus.*
2. *Cavicolae.* Larvae found in the frontal sinus, nasal cavity and throat of the Cavicornia, Tylopoda, Cervidae, Proboscidea, and Equidae. Ex. *Oestrus.*
3. *Cuticolae.* Larvae occurring under the skin of Cavicornia, Cervidae, Equidae, and Rodentia. Ex. *Hypoderma.*

B.—*Cuterebridae.*

Larvae occurring under the skin of Marsupialia, Ungulata, Carnivora, Rodentia, and Man. Ex. *Dermatobia.*

Brauer enumerates sixteen genera belonging to the family, and a few have been added since.

II.—The Life-history of *Hypoderma bovis* (De Geer).

Historical.

The Ox Warble Fly was first figured by Réaumur in his well-known "Memoirs pour servir à l'historie des Insectes"; he referred to it as "l'oestre du boeuf." It was De Geer, however, who gave it its first name—*Oestrus bovis.* In 1825 Latrielle removed it from the Linnean genus *Oestrus* and placed it in a new genus, *Hypoderma,* and the insect is now generally known as *Hypoderma bovis.*

The earliest reference and figures of the larva occur in the works of Vallisnieri, dated 1710, but at that time the fly was unknown. In 1797 the veterinary surgeon Bracy Clark gave an excellent account of the life-history of the insect. He described and figured the larva, the pupa, and the imago, and suggested means against its ravages. The facts brought to light by him have left little or no need for correction or modification by later writers, and his description forms the basis of what little is known of the biology of *H. bovis* to-day.

In 1846 Joly published an extensive series of observations on the *Oestridae,* including some account of the anatomy of the group.

In 1863 Prof. Brauer brought out his "Monographie der Oestriden," and it is still the standard work on the subject. It contains a full bibliography of all works relating to the family up to that year, but, except for figuring the egg and giving some account of certain structural features in the larva, his account does not add very much to Bracy Clark's observations.

No further contributions were made to a knowledge of this insect until Miss Ormerod commenced her enquiry into its life-history and

ravages in 1884. Her observations extended over a period of ten years, and were published in yearly reports as the work proceeded. In this work she enlisted the services of a number of voluntary observers, principally farmers and hide merchants, over various parts of the country, and the final results of the investigation were published in 1894. The observations deal with the injuries caused to the cattle and to the hides, and a great deal of valuable statistical information is brought to light. Some account is also given of the structure and life-history of the larva.

In 1898 Koorevaar published some important observations on the wanderings of the *Hypoderma* larvae in the tissues and various organs of cattle. He believed that the larvae were those of *H. bovis*.

Most of what is known concerning this insect is comprised in the above works. A full list of the earlier writings is given by Brauer ('63), and the later contributions will be found in the bibliography at the end of this paper.

The Egg.

The eggs of *Hypoderma bovis* are described by Brauer ('63, p. 127) as follows. "Longish elliptical, flattened, white, with a large brownish appendage at the hinder pole. Length, 1¼ mm." He was not aware as to the method of oviposition, and remarked that the question was still obscure, but did not think that they were inserted into the hide.

Although the eggs were unknown to Bracy Clark, the latter appears to have observed the female fly depositing them. He remarked ('96, p. 297) that she was extremely quick in performing the act, and did not appear to remain on the back of the animal more than a few seconds. In his later writings ('43, p. 81) he called attention to the important fact that the female has no instrument for inserting the eggs under the skin. He described the ovipositor as being a tube made of flexible materials, piece inserted into piece after the fashion of a telescope.

Miss Ormerod was at first strongly inclined to believe that the eggs were deposited *under* the skin, but in her later writings she gave up the idea as being contrary to facts. She pointed out that there was every reason to believe that the fly deposited them on the hairs of the skin.

The appendage of the egg, referred to by Brauer, differs in no essential features from that found on the egg of the closely allied species *Hypoderma lineata*. With regard to the eggs of the latter species, Riley ('92, p. 307, fig. 44) remarks that he found them placed four to six together on a single hair, and that the structure of the lower portion of each egg (*i.e.*, the appendage) is perfectly adapted for clasp-

ing the hair. It consists of two lobes or valves forming a bulbous enlargement, which is attached to the base of the egg by means of a broad but rather thin neck. When the egg is laid these lips or valves close over the hair, and thus give a very secure attachment. In the light of Riley's observations on the eggs of *H. lineata*, there can be very little doubt that those of *H. bovis* are similarly deposited on the hairs of cattle. Most observers believe that the seat of oviposition is the middle line of the back on either side of the spine, about the region of the shoulders. Accurate observations on this point, however, are greatly needed, for there seem to be no records in literature of anyone having found the eggs of this species on the cattle themselves. Both Joly ('46, pl. iv, figs. 10 and 11) and Brauer ('63, pl. viii, fig. 1a) figure the eggs, but they have done so by obtaining them directly from the bodies of the female flies.

THE LARVA.

First Instar.—The very young larvae described and figured by Miss Ormerod ('94, p. 3) as belonging to this species are probably in the first instar of their life-history, especially as they agree very closely with the newly hatched larvae of *H. lineata*. They measure about $\frac{1}{4}$in. in length, and $\frac{1}{16}$in. in width. They are worm-like in shape, consist of twelve segments, and are provided with a pair of extremely minute crescent shaped chitinous mouth-parts. The larvae are whitish in colour and transparent; they are marked with sixteen short transverse bands of very minute dark grey prickles, which are placed for the most part in alternate narrow or broader stripes.

In *H. lineata* the *Second Instar* is characterised by the larva being quite smooth and devoid of prickles, except for a few minute ones in relation with its two extremities, and, moreover, the mouth-parts become more prominent. Larva in this instar measured 11-14 mm. long. In *H. bovis* no larvae in this stage have yet been discovered. Most likely they have been overlooked, especially as the early life-history of the species has been so little studied. It does not seem probable that in two such closely allied species this instar should be present in the one but absent in the other.

Third Instar.[1]—A figure of the larva in this instar is given by Joly ('46, pl. iv., fig. 12), Brauer ('63, p. 127) has enumerated its salient features, and it is also described by Miss Ormerod ('94, p. 5). According to Brauer, it measures 13 mm. long and 4 mm. wide at the fourth segment. It has lost its cylindrical, worm-like form, and has become spindle-shaped. It has an extensive armature of prickles on its ventral surface, but on the dorsal side they are restricted to the second and

[1] This instar corresponds with Stadium 2 in Brauer's description of the larva.

third segments. The tracheal system opens to the exterior by means of a pair of spiracles, situated at the hinder extremity of the body. They are in the form of a pair of short and horny, somewhat blunt, projecting tubes, which are provided at their extremities with a number of round or oval discs.

Fourth Instar.[1] In this last stage the larva assumes its well-known appearance, and it is described and figured in almost all the writings which treat of the life history of this insect. It varies in length from 22-28 mm., and measures 11-15 mm. wide across the eighth segment. It is bluntly oval in form, and somewhat compressed, and has a warty appearance. The skin has become greatly thickened, and a powerful coat of sub-cutaneous muscles is developed. The prickles are much larger and more numerous than in the previous instars; they are arranged for the most part in an anterior and posterior transverse series on the 2nd to 8th segments, they are wanting from the dorsal surface of the 9th segment, and are completely absent from the 10th and 11th segments. In this final stage the hard tips of the spiracles are lost, having been discarded during the previous moult. They are replaced by a pair of kidney-shaped structures which are sunk within an oval depression situated at the hinder end of the body.

Miss Ormerod ('85, p. 190) divides the larval history of *H. bovis* into the following three periods: (1) When its chief business is to eat its way through the skin to reach the sub-cutaneous tissue beneath; (2) in which it works its way up to the skin again in order to obtain free communication with the atmosphere; (3) when it lies within the warble or sub-cutaneous cyst and becomes nourished on the products of the inflammation which its own presence causes.

The mode of occurrence of the very young larvae is described by Miss Ormerod as follows ('94, p. 3). "On November 12th, 1884, a cutting from a yearling skin brought in that day was forwarded to me by Messrs. C. and H. Hatton, Barton Tannery, Hereford, with a note that they considered that it showed first symptoms of warble-maggot. This piece of hide was about 12in. by 4in., and on the *flesh side* there were upwards of seven slight swellings about a quarter of an inch across, of a livid or bluish colour, each forming a raised centre to greatly inflamed patches. Within the blue centre I found a small warble maggot, just large enough to be distinguished by the naked eye when removed, but not plainly so whilst in the swelling, as the inside of this was of blood-red tissue, and *the small maggot was blood-red also.*" She further remarks that from each of the swellings a fine channel, no wider than a hair, passed up through the hide to the surface. These channels when examined under the microscope were found

[1] Corresponding with Stadium 3 in Brauer's description.

to have jagged or gnawed walls, apparently caused by the young larvae eating their way from the surface, through the hide, to the sub-cutaneous tissue below. The fact that these tiny channels are frequently curved for a part of their course, the possibility of their having been made by the ovipositor of the female fly is thus obviated.

During the second part of its life-history the larva has increased somewhat in size and passes through the stage which, as has been pointed out, is probably its third instar. During this period it devotes itself to working its way upwards from the sub-cutaneous tissue below so as to reach near to the surface of the skin. It works itself tail foremost, and uses its hard pointed spiracles to force open and gradually enlarge the fine passage it made during the previous period.

In the third period the larva, having found and enlarged the first opening, lies with the tail end, containing the spiracles, lodged in the passage, and with its body hanging head downwards within the sub-cutaneous cyst or warble. The passage or channel at first has merely jagged walls, but subsequently it becomes lined by a definite membrane of connective tissue continuous with that lining the warble cavity. This period is wholly devoted to growth, and it is essential that the larva should have free access to the atmosphere for respiratory purposes. It lies the whole time within the warble in the position described until it is about to change into the pupa. The significance of the formidable armature of prickles with which the larva is provided at this period is explained by Bracy Clark as follows ('96, p. 292). "These hooks," he remarks, "it is probable are occasionally erected by the muscles of the skin, and according to the series of them used by the larva, it is raised or depressed into the abscess; and by the motion, and the consequent irritation, a more or less copious secretion of pus is occasioned for the sustenance of the larva."

The above account is a résumé of what is believed in this country to be the normal life history for the larva. Other observations, which have been made on the Continent, tend to prove, however, that previous to the stage when the warbles are formed the course of the life-history may be something entirely different.

In 1888 a Dutch veterinary surgeon, Hinrichsen ('88, p. 219), published an account of an examination of twenty-five carcases of slaughtered cattle. In ten of these he found small larvae lying between the periosteum and dura mater in the spinal canal. With some hesitation he regarded these larvae as being those of *H. bovis* in their first stage of development. In 1895 he published some further observations of a similar nature ('95, p. 106). Similar observations have been published by Horne ('94, p. 33, and '95, p. 126), who was inclined to regard the spinal canal as being the normal resting place for these larvae. Ruser, in 1896, reported that in four oxen, which had warbles under

their hide, he found transparent larvae embedded in the wall of the oesophagus. He believed that they bored their way through the latter and reached the course of the great vascular trunks and nerves of the neck. From there they wandered to the sub-cutis of the back, and some also found their way through the inter-vertebral spaces into the spinal canal ('96, p. 127). Some additional remarks and observations have been made by Schneidemühl ('97, p. 752, and '98, p. 30) and Koorevaar ('98 (1), p. 29, and '98 (2), p. 888). Koorevaar's observations are of great importance. During the months of January, February, and March a number of slaughtered cattle were examined by him, and small larvae were frequently met with both under the skin in warbles and in the spinal canal of the same animal. Neither in size nor in form did the largest spinal larvae differ from the youngest of the larvae found under the skin. In frequent instances larvae were found to have crawled out of the spinal canal and were lying in the inter-vertebral spaces, and in one case a larva was found lying between the neural spines. On February 28th a yearling beast was found with many larvae beneath the skin, and it had three in the spinal canal, and thirteen were found embedded in the connective tissue of the oesophagus, between the mucosa and muscularis layers of the latter. The oesophageal larvae were in all respects similar to those found in the spinal canal. Larvae were found in the walls of the gullet on two occasions afterwards. On one occasion Koorevaar inserted eleven spinal larvae from a calf beneath the skin in the left lumbar region of a small dog. The experiment was performed under antiseptic precautions, and the incision soon healed. Eight days later, in the same manner, fifteen more of the larvae were introduced under the skin of the right side. A period of fourteen days were allowed to elapse, and then the dog, which remained quite normal, was dissected. Five of the larvae were found still beneath the skin, and, of these, one was found in the left costal wall, one in front of the shoulder, one in the right thigh, one on the skull, and a fifth on the jaw. Six of the larvae were found lying free in the peritoneal cavity between the folds of the intestine, and a further five were discovered in the fat of the spleen, kidneys, omentum, inguinal canal, and the retroperitoneal tissue respectively. On removing the kidneys three were found on the psoas muscles, and three more were met with in the wall of the oesophagus, two others in the peritracheal tissue, and two in the spinal canal between the dura water and periosteum. Thus, as he remarks, all the twenty-six larvae are accounted for, and they were for the most part alive. It is noteworthy that the wanderings should have taken place in so short a time after they had been introduced under the skin. No tracks or traces of their migrations could be detected in any part of the animal in spite of a careful examination. From these experiments, and from

the observations made on oxen, Koorevaar inclines to the opinion that the young larvae of *H. bovis* at first pass beneath the skin, and from thence betake themselves to the spinal canal and other places. They return later to the sub-cutis, and there complete their development under the well-known conditions. Quite recently T. P. Koch ('03, p. 129) has contributed some observations on the occurrence of these larvae in oxen. In their earliest stage he has found them abundantly both in the walls of the oesophagus and under the skin. In the case of those in the gullet he has found them as early as July in that position, and at that time they measured only 2 mm. long. He believes that they remain there for eight or nine months, having found them plentifully up to March. In the months January-March larvae were also plentiful in the spinal canal. The presence of the larvae in the oesophagus causes a certain amount of pathological change in the latter; some remarks on this subject are contributed by Jensen ('03, p. 169).

From the evidence given above it is reasonable to conclude that there are at least three possible courses for the life-history of the larva of *H. bovis*, viz.:—

> That the larva on hatching immediately eats its way through the hide and wanders for a short distance in the sub-cutaneous tissue. It eventually returns to the surface and gives rise to the well-known tumours or warbles (Ormerod and others).
>
> Or, having bored its way through the skin, it wanders very extensively in the tissues of its host, frequently entering the spinal canal through the intervertebral spaces. In other instances the larvae wander to the oesophagus and become embedded in its walls. In both cases they subsequently return to the sub-cutis, and there complete their development (Koorevaar).
>
> Or, that the larvae do not bore through the skin at all, but are taken into the throat of the ox by means of the latter licking parts of its body where the eggs are deposited. On reaching the oesophagus they hatch out from the eggs, and slowly bore through the walls of the former. They then wander about the tissues of the animal, working their way upwards at the same time, and not infrequently effect an entrance into the spinal canal. Eventually they reach the skin as before (Ruser and others).

Which of these possibilities comes nearest to what really takes place during the *normal* life-history of the larva cannot be decided in the existing state of our knowledge. It is necessary to point out that this important question can only be ascertained by means of prolonged and carefully conducted experiments made with the cattle themselves.

How long the insect spends in the larval state is at present un-

known. The fact that the flies themselves are found during the summer, while the small larvae have been found in the tissues of oxen during the winter months by Koorevaar, Koch, and the other observers quoted, seems to indicate that, during the early part of the larval history, growth is extremely slow, though the larvae may migrate a good deal in the tissues of their host. This period in the life-history of the *Oestridae* is discussed by Brauer ('92, p. 79), who terms it the "stillstadium"; he points out that a period of remarkably slow growth occurs among the larvae of other members of the family, notably in *Hypoderma diana*, and in *Cephenomyia*. During the "warble period" of the larval history growth appears to be comparatively rapid, and takes place during the spring and summer. This is supported by the fact that the trade reports show very few warbled hides between the months September-February.

The larvae are chiefly found in yearling and two-year-old beasts; older animals appear to be to a large extent exempt from the attacks of this insect.

It is further noteworthy that there are on record very numerous instances in which *Hypoderma* larvae have been found under the skin in man, where they have often wandered extensively for considerable periods. In such cases it has not been possible to determine to what species of the genus they belong, but they are usually regarded as being those of *H. bovis*. Prof. Schöyen, the Government Entomologist, Christiania, states that he has very little doubt that in Norway the larvae are those of *H. bovis*. He remarks that it is with persons who attend the cattle during the summer months that such larvae are to be found during the winter. It is evident that the smell of the cattle about the clothes of those individuals attracts the flies for the purposes of oviposition. Schöyen gives a résumé of all such instances that have been recorded from various countries up to 1886 ('86, p. 171).

The Pupa.

When the larva has reached maturity, and become full-fed, it gradually works its way out of the warble through the opening by means of which the latter communicates with the exterior. In virtue of the pressure which the larva exerts the aperture of the warble becomes somewhat enlarged, and the grub, aided by the prickles of its skin, which prevent it from slipping backwards, squeezes itself through and falls to the ground. On reaching the earth it is said to seek for the nearest shelter at hand, usually a clod of soil or a neighbouring stone, and there pupates.

From observations supplied to Miss Ormerod, it was found that the full fed larva worked its way out of the warble in the morning,

or at some time between 6 o'clock in the evening and 8 a.m. the next day. This point was ascertained by smearing bird-lime around the warbles, or by fixing little bags close to the apertures of the latter for the larvae to fall into. By this means it was discovered that the larvae never left the warbles during the middle of the day ('94, p. 11). It is also noteworthy that this habit of the larvae was known to Réaumur, and the latter observed that they usually emerge from the warbles about 6 o'clock in the morning.

The pupa is formed within the old larval skin; in appearance it bears a good deal of resemblance to the larva, but differs from it in being brown or almost black, and somewhat flattened on one side.

According to Miss Ormerod, observations which were conducted on eighteen pupae demonstrated that the pupal stage lasts about twenty-five days. To ascertain the effect of cold upon them, four pupae were placed at a temperature much below the normal. Under such conditions it was found that an average period of twenty-six days was required for the emergence of the perfect insects, and, moreover, it was found that the latter were poorly developed specimens.

The Perfect Insect.

The fly escapes by forcing open a peculiar sub-triangular lid situated at the anterior end of the puparium.

It is a remarkable fact that, notwithstanding the abundance of the larvae in the cattle of this country, the imagines of *H. bovis* are but seldom caught, and scarcely anything is known concerning their habits, even by professed entomologists.

There is some reason to believe that warble flies are to be met with all through the summer, though most writings, which deal with the subject, mention late July and August as being the time when it is on the wing. The only two specimens of *H. bovis* in the collection of the British Museum bear the dates 25/6/96 and 13/8/96. Furthermore, as Miss Ormerod points out, the time of presence of the larvae extends (as shown by trade reports of conditions of hides) from February to September, and the probability is that the season of the flies, to which these larvae turn, extends to some degree over many months of the year, and the date of egg-laying would vary conformably.

It is said that the very presence of this insect strikes terror into the cattle, and causes them to break into the wild stampedes which are familiar to farmers and others who live in country districts. When thus tormented, it is said that they rush into the nearest pond or stream, should there be either at hand, and it is believed that the Warble Flies do not follow them across water. It cannot, however, be regarded as proved that this fly is responsible for these disturbances among the

cattle, and that they are not the result of sharp pricks through the skin[1] inflicted by blood-sucking Diptera, which are plentiful during the summer months. Those who have observed Warble Flies agree that they fly with great rapidity, and that consequently they are very difficult to follow with the eye. Popular observations are therefore not of much value unless they have a very considerable array of facts to support them.

III.—THE INJURIES CAUSED BY *Hypoderma bovis*.

The injuries effected through the agency of *Hypoderma bovis* are of a very extensive description, and are well known over the larger part of Europe. In addition to Great Britain, they have attracted the attention of investigators in Scandinavia, Germany, Holland, France, Italy, Austria, and Russia. They are of a three-fold nature:—

A. Those occasioned to the hide merchant and the tanner.—These are by far the most extensive. The perforations of the hides caused by the larvae detract very greatly from the value of the former. The extensive enquiries undertaken by Miss Ormerod ('94, p. 31) from various hide-merchants and tanners distributed over various parts of Great Britain have resulted in a very considerable mass of carefully compiled statistical evidence being brought together. They are too extensive to be quoted here *in extenso*, but a few extracts from her reports are given herewith.

During the year ending May, 1888, 102,877 hides passed through the Newcastle market, and out of these 60,000 were more or less injured by the larvae of *H. bovis*, and resulted in a loss to the trade of £15,000.

In the Nottingham market 35,000 hides passed through during the year, and 8,500 of them were "warbled." The estimated loss to the trade was £1,500 to £2,000.

In January to December of the same year 250,740 hides went through the Manchester market, and 83,580 were more or less badly warbled. The year's loss amounted to £16,716.

Taking the average from all the sources from which returns have been received, Miss Ormerod estimates that from five to six shillings is lost on every warbled hide.

Warbled hides find their way into the markets during the months February to September, but reach their maximum during April and May.

B.—Those occasioned to the butcher.—The presence of warbles under the hide of an animal produces a chronic state of inflammation, and very evident alteration in those tissues situated immediately beneath

[1] The Warble Flies are incapable of inflicting pain in this way on account of their mouth-parts being atrophied.

the infected parts of the skin. This results in the production of what is known to the trade as "licked beef" or "jelly." When a hide is stripped from a carcase, the "licked beef" is readily seen as straw-coloured, jelly-like patches on the surface of the meat. When exposed to the air it turns in the course of twelve to twenty-four hours a dirty greenish colour, and has a frothy discharge oozing from the surface with a soapy-like look. This substance greatly deteriorates the quality of the meat, and, as the whole of the infected part of the latter has to be cut away, a great loss is entailed to the butcher, especially as it is usually found on the most expensive parts.

The average loss to the butcher is computed at about six shillings and eightpence for every infected carcase.

C. Those occasioned to the stock-raiser and the dairy farmer.—All stock-raisers and farmers are cognisant of the mischief that arises from the wild gallops which the cattle take when tormented by this fly.[1] These gallops occasion, even in a healthy animal, a delay in fattening, and are especially injurious to incalf cows, as well as causing a deterioration in the quality and supply of the milk. If the animal contains at the same time from six to a hundred rapidly maturing larvae the effects become still more deleterious to its health and comfort. Under these circumstances very considerable exhaustion must ensue, especially as the cattle are principally plagued by the flies in the warm weather, and it means a loss to the stock-raiser when the animals are sold on account of the reduction in weight which has taken place.

It is difficult to estimate the pecuniary loss which is incurred from these effects, and the question has not been inquired into in this country. In America, similar mischief is caused by the larvae and flies of *H. lineata*, and together they incur an estimated loss of 28 % through reducing the quantity of milk produced and deteriorating its quality. If the loss of flesh be taken into account as well, it would raise the amount a further 5 to 10 %.

The aggregate loss occasioned by *H. bovis* in England has been variously estimated at from 2 to £7,000,000 per annum, and an average loss of £1 per head of all horned cattle is considered by some authorities as being rather an under-estimation of the extent of the injuries.

IV.—Remedial Measures.

Many remedial measures have been suggested, but in all instances the greater part of the damage has been done before they are applied, and they merely serve to arrest any further injury.

[1] Vide on this question p. 83.

They consist of:—

(*a*) The application to the warbles of various smears and dressings for the purpose of killing the larva by choking up its breathing apparatus.

(*b*) By squeezing the larvae bodily out of the warbles. This operation, however, can only be performed if they be sufficiently advanced in development (and consequently after the greater part of the injury has been done) to allow of the process.

Preventive measures have also been recommended, and consist of the application of suitable washes and dressings, such as may make the coat of the animal obnoxious to the fly, and so prevent it from "striking."[1] Such dressings may also perhaps be effectual in destroying the vitality of the eggs, or may kill the newly hatched larvae, but they are too cumbrous and expensive to be of any practical value when large numbers of cattle have to be dealt with. It has been further suggested that shelter, natural or artificial, should be offered to the cattle when they are put out to graze, and that the animals should have access to ponds or streams, as it is believed that the flies never follow them across water.

At present, on account of the lack of knowledge of so many important questions in the life-history of the larva, and the total absence of any corroborative information regarding the habits of the perfect insect, no preventive measures can be recommended with any degree of confidence. The destruction of the larvae after they have reached the skin, and have consequently committed most of their mischief, is only to be urged in the absence of a more effective and practical method of dealing with this parasite.

V. THE LIFE-HISTORY OF *Hypoderma lineata* (VILLERS).

Hypoderma lineata was first described by Villers as *Oestrus lineatus* in 1789. It was subsequently described by Brauer, from larvae only, who in 1875 named it *Hypoderma bonassi.* The larvae were taken from the American Bison, and were sent to him by Dr. Hagen. Bracy Clark, in his "Essay on Bots, etc." (1815), considered it to be a variety of *H. bovis*, and later (1843), regarded it as the female of that insect. In 1853 Walker described the insect from Nova Scotia as *Oestrus supplens.* At the time of Brauer's "Monographie der Oestriden," the larva of *H. lineata* was unknown, and in that work the author, on the authority of some observations made by Winnertz, sug-

[1] According to Bracy Clark ('43, p. 83), Pliny, who was acquainted with Warble Flies, advised protecting the cattle from attack by annointing them with fats and oils.

gests as its probable hosts the sheep and the ox ('63, p. 124). It was not until 1890 that Handlirsch and Brauer definitely proved that it was parasitic in cattle ('90, p. 509).

It is in America that the life-history of this insect has attracted the largest amount of attention, and a good deal has been written on the subject in that country. Prior to 1891 the species was believed to be *H. bovis*, but in that year Riley [1] proved that it was *H. lineata*, and not *H. bovis*, that was causing the mischief in the United States. There is no evidence up to the present to show that *H. bovis* occurs in that country at all (Aldrich, '05).

Some remarkable observations have been made concerning the larval habits of *H. lineata* by Curtice, of the U.S. Bureau of Animal Industry; they were conducted during the months November to February. A preliminary account of them was published by Curtice in 1890 ('90, p. 207), and the full description a year later ('91, p. 265). In November young larvae were found by him in the walls of the eosophagus in a number of slaughtered cattle, and at the end of December they also occurred in plenty under the skin of the back. The earliest larvae that were found beneath the skin in nowise differed from those taken from the oesophagus. By the end of January, and the beginning of February, the larvae had all disappeared from the oesophagus together with all the traces of the inflammation they had caused. They were found to have pierced through the oesophagus and wandered in the tissues of the back, and were met with under the pleura in the region of the 11th rib, also in the spinal canal and in the sub-cutaneous muscles and connective tissue. On the inside of the freshly removed hides, which contained larvae in their first instar, small gnawed holes, which he regarded as being caused by the latter, were found. On reaching a suitable spot on the back, he believed that they bored through the skin caudal end foremost. Larvae of the second and later instars were only found within the warbles, and as the ecdyses of the first and second moults were found there with them, they were the means of connecting together the various stages. Altogether Curtice found among the cattle he examined 200 larvae in the oesophagus, 45 in the "first skin stage," or second instar, in the dermis, 150 in the "second skin stage," or third instar, and 550 in the "third skin stage," or fourth instar. As the result of these observations, he suggested that the cattle lick the eggs or young larvae from off their backs, and that the larvae eat their way into the oesophageal walls. From thence they work through the tissues in the region of the 11th rib, and eventually reach the skin to complete their development.

[1] *Insect Life*, vol. iii. p. 432.

Riley accepted Curtice's views with some caution, and remarked that tne question in his mind was whether this mode of development was not exceptional, and whether direct penetration into the skin did not also occur. It resulted in his further investigating the life-history and the evidence which he has collected very strongly supports Curtice's conclusions. The principal results in Riley's work ('92, p. 302) are as follows. The eggs may be laid on various parts of the body that can be reached by the tongue of the animal, but the fly exhibits a very strong prediliction to deposit them on the flanks and legs around the heels, hence the American name of "Heel Fly."[1] This fact explains the almost universal habit the cattle have of seeking to protect their legs by standing in the water during the bot-fly season. The fly does not seem to attack the cattle while in the water, even though they may be standing on rocks protruding from the water, so that no part of their legs was submerged. When the cattle lick themselves, Riley believes that the young larvae are licked up by the tongue of the animal, either directly out of the egg, as happens in the case of the Oestrid *Gastrophilus equi*, or, as must often happen, they are taken up while still in the egg, and together with the hairs to which the latter are attached. It is noteworthy in this connection that the egg-laying season is coincident with the season for shedding the hairs, and it is at this period of the year the cattle have a great habit of licking themselves. The larvae in either event seem to need the warmth and moisture of the animal's saliva for their well-being. On hatching they are provided with minute spines over the greater part of their body, which enable them to adhere to the walls of the oesophagus. Having reached the latter situation they soon moult, and assume the second instar or smooth stage, and in this condition they bore through the oesophageal walls and then wander slowly in the tissues of their host for some eight or nine months, growth being extremely slow throughout that period. During the late winter they reach a point beneath the skin in the region of the back, and there penetrate the skin, probably anal end foremost. Here they moult for a second time, and, passing into the third instar, reassume their spinose character. They henceforth develop rapidly, and cause a great deal of inflammation. The third moult soon takes place, and the larvae become still more spinose and live in the fully developed warbles so well known to the stockmen.

In Britain scarcely anything is known concerning *H. lineata*, and it is only comparatively recently that the species has been shown to occur in the country. The evidence afforded by the series of specimens in the collection of the British Museum shows, as Austen has pointed

[1] Oviposition was witnessed early in March.

out ('01, p. 94), that it is the commoner species of the two. I have examined the specimens, and find that they number fifteen in all, and of which only three are females. They were caught on dates varying from the end of April to the beginning of June. In view of the fact that the national collection only contains two *H. bovis*, compared with fifteen *H. lineata*, it is probable that the latter is the commoner species, and that much of the information published by English observers as pertaining to *H. bovis* really concerns *H. lineata*.

How far the life-histories of the two species coincide with one another it is impossible at present to say, and the problem of investigating them is further complicated by the fact that, according to Brauer ('90, p. 509), larvae of both species may occur in the tissues of the same animal.

While preparing the above paper I was indebted to Dr. D. Sharp, F.R.S., for generous assistance rendered to me in various ways, and I take this opportunity of acknowledging it with my best thanks.

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'88. **Hinrichsen,** .—Ueber einen neuen Parasiten im Ruckenmarkskanal des Rindes. *Archiv. f. wiss. u. prak. Thierheilkunde*, 1888, Bd. xiv. (Abstract in *Centralb. f. Bakter., Parasitenk. &c.*, 1888, Bd. 3, p. 698.)

'95 **Hinrichsen,** .—Weitere Bemerkungen über das vorkommen von Oestruslarven im Ruckenmarkskanale des Rindes. *Zeitschr. f. Fleisch- u. Milchhygiene*, 1895, Heft 6. (Abstract in *Centralb. f. Bakter., Parasitenk. &c.*, 1895, Bd. 17, p. 681.)

'94. **Horne, H.**—Bremselarver i Rygmarvskanalen og Kjödet hos Oxen. Norsk Tidsskrift for Veterinärer, 1894, vi. (Abstract in *Centralb. f. Bakter., Parasitenk. &c.*, 1895, Bd. 17, p. 846.). Vide also *Zeitschr. f. Fleisch- u. Milchhygiene*, 1895, Heft 7, p. 126.

'03. **Jensen, C. O.**—Om de af *Hypoderma*-Larver foraarsugede pathologische Forandringer i Spiserõret hos Kvœget. *Maanedsskrift for Dyrlægar*, 1903, Bd. xv.

'46. **Joly, M. N.** Recherches zoologiques, anatomiques, physiologiques, et medicales sur les Oestrides èngénéral et particulièrement sur les Oestres qin attaquent l'homme, le cheval, le boeuf, et le mouton. *Ann. des Scienc. Phys. et Nat d'Agric. &c. de Lyon*, 1846, T. ix.

'98 (1). **Koorevaar, P.**—De larvetvostand van *Hypoderma bovis*. *Tijdschrift der Nederlandische Dierkundige Vereenigung*, 1898, 2 de ser., deel v. (Translation by Austen in *Ann. Mag. Nat. Hist.*, 1899, ser. 7, vol. 4, p. 69.)

'98 (2). **Koorevaar, P.**—*Hypoderma bovis* und ihre jüngsten Larven. *Centralb. f. Bakter., Parisitenk. &c.*, 1898, Bd. 23, p. 888.

'03. **Koch, T. P.** Oksbremsen (*Hypoderma bovis*), spec. Larvens udvickling og vandring i Krœgets Legeme. Maanedsskrift for Dyrlœger, 1903, Bd. xv. (Abstract in *Centralb. f. Bakter., Parisitenk. &c.*, 1904, Bd. 34, p. 723.)

'05. **Neumann, L. G.**—A Treatise on the Parasites and Parasitic Diseases of the Domesticated Animals. Translated by Fleming; 2nd Ed. revised and edited by Macqueen. London, 1905. (*H. bovis* is dealt with in Chap. ii; the account, though good, requires revision.)

'85. **Ormerod, E. A.**—Observations on the Development of Ox Warble and Warble Maggot. *Journ. Roy. Agric. Soc.*, 1885, vol. xxi, s. 2.

'94. **Ormerod, E. A.**—Observations on Warble or Ox Bot Fly, *Hypoderma bovis* De Geer. 8vo, London, 1894. (Vide also the Annual Reports on Injurious Insects published by the authoress for the years '84, '85, '86, '88, '89, '90, and '91.)

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'92. **Riley, C. V.**—The Ox Bot in the United States. Habits and Natural History of *Hypoderma lineata*. *Insect Life*, 1892, vol. iv.

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'97. **Schneidermühl, G.**—Neures zur Entwicklungschichte der Bremsenlarven des Rindes. *Centralb. f. Bakter., Parasitenk.* &c., 1897, Bd. 22.

'98. **Schneidermühl, G.**—Zur Entwicklungschichte von *Hypoderma bovis*. *Centralb. f. Bakter., Parasitenk.* &c., 1898, Bd. 24.

'86. **Schoyen, W. M.**—Om forekomsten af Dipterlarver under Huden Hos Mennesker. *Ent. Tidskr.*, 1886, vii. (Quoted from Riley, *Insect Life*, iv, p. 310.)

REVIEWS AND CURRENT LITERATURE.

I.—General Subject.

Flatters, Abraham.—Methods in Microscopical Research—Vegetable Histology. Pp. x + 116, 23 cold. plts, and 29 text figs. London: Sherratt and Hughes, 1905.

Mr. Flatters is to be congratulated on the production of this very practical and useful work, which deals with the subject of practical microscopy as applied to vegetable histology, in an admirable and very thorough manner. No microscopical or natural history society worthy of the name can afford to be without a copy of this work. It cannot fail to aid and stimulate workers and excite them to obtain better results than in the past. The illustrations are excellent.

W. E. C.

Henneguy, L. Felix.—Les Insectes; Morphologie—Reproduction—Embryogénie. Leçons recueillies par A. Lécaillon and G. Poirault. Pp. xviii + 804, 622 figs. and 4 cold. plts. Paris: Masson et Cie, 1904.

This fine work is intended, as its author remarks, rather as an introduction to Entomology, and to serve as a complement to the well-known treatises of Kolbe and Packard, than as a complete text-book. The particular subjects which are inadequately treated in those works are here dealt with, for the most part, very fully. This method of treatment accounts for the very unequal merit to be found among the various sections of the book. Insects are dealt with from three aspects, viz.:—Morphology, Reproduction, and Development; the subject of "natural history" is not gone into in this work.

The section devoted to Morphology, on the whole, does not add very much to what can be found in Packard's text-book. The first 66 pages are devoted to an introduction and to the external morphology of insects. Chapter II treats of the digestive, circulatory, and respiratory systems, together with the fatty body and the tissues derived from it. We think that the short but excellent account of the luminous organs is the best we have yet seen in any text-book; it is illustrated by excellent original figures. Chapter III deals with the muscular and nervous systems and the organs of special sense. The part devoted to the muscular system is extremely brief, and is based almost wholly on Janet's histological researches. We would have liked to have seen some attempt towards an account of the general arrangement of the muscles among Insects, which is a desideratum in all books yet written.

The section dealing with the various phases of Reproduction is extremely valuable. The fifty pages given to the difficult subject of parthenogenesis we commend to the attention not only of every student of the Insecta, but to the general zoologist also.

The remainder of the book, comprising some 500 pages, deals with Development. The first two chapters of this section relate to the embryology of Insects, and may be regarded as a supplement to the account given in Korschelt and Heider's well-known *Lehrbuch*. The rest, comprising seven chapters, deals with post-embryonic development. Some general remarks are given to the subject of metamorphosis, and then follows a comparative description of the external and internal anatomy of Insect larvae, which, in itself, forms a unique feature in the book. The succeeding chapter deals very fully with the processes of histolyses and histogenesis, and includes much information from the recent researches of Perez and Anglais. The book concludes with an account of the development of the sex cells, some remarks on the general problem of metamorphosis, and an extremely valuable bibliography of general Entomology. The Bibliography is remarkably complete and well chosen, and contains about 2,500 references including papers up to the end of the year 1902. Difficult as it is to avoid missing, at times, even important papers in a subject with so extensive a literature, we should like to call the author's attention to the omission of Fernald's paper on the Relationships of Arthropods (1890), Sasaki's account of the parasite *Ugimyia* (1886), and Folsom's important papers on the mouth-parts of the Collembola (1899 and 1900).

The printing of the book and the method of illustration leave nothing to be desired. Many of the figures are taken from the more recent researches, and have not previously found their way into any text-book.

A. D. IMMS.

Kellogg, Vernon L.—American Insects. Pp. vii + 674, 13 cold. plts. 812 text figs. Westminster: Archibald Constable & Co., Ltd., 1905.

Professor Kellogg has written an admirable work on general entomology that cannot fail to at once arrest the attention and rivet the interest of the merest tyro.

As stated in his preface, "the book is written in the endeavour to foster an interest in insect biology on the part of students of natural history, of nature observers, and of general readers; it provides in a single volume a general systematic account of all the principal groups of insects as they occur in America, together with special accounts of the structure, physiology, development, and metamorphoses, and of certain particularly interesting and important ecological relations of insects with the world around them. Systematic entomology, economic entomology, and what may be called the binomics of insects are the special subjects of the matter and illustration of the book."

The chapters on insects and flowers, colour and pattern and their

uses, and insects and disease, will at once awaken in the reader a desire to know more of the mysteries of insect life, and at a time when biologists are attacking some of the most important biological problems with insects as their material and data, a work of this character is especially opportune.

The systematic portion suffers for want of space.

W. E. C.

Packard, A. S.—Monograph of the Bombycine Moths of North America, including their Transformations and Origin of the Larval markings and armature. Pt. II. Mem. Nat. Acad. Sci., Washington, 1905, vol. ix, pp. 1-272, plts. i-lxi, and 19 text figs.

This is a beautifully illustrated volume, treating of the sub-family *Ceratocampinae* under the following heads: Colouration and protective attitudes of the *Notodontidae*. The larval armature of the *Ceratocampinae*. The caudal horn of the *Ceratocampidae*. Protective armature both in shape and colour, and defensive movements. Colouration in the larval of the *Ceratocampinae*. Dichromatism or colour variation in the larva. Life history of *Ceratomia amyntor*. Phylogeny of the *Ceratocampinae*. On the Phylogeny of the *Sphingidae;* their derivation from the *Ceratocampidae*. Origin of the *Syssphingina*, and also the *Symbombycina* from the *Notodontidae*. Opisthenogenesis, or the development of segments, median tubercles, and markings *a tergo*. The superfamily *Syssphingina*. Origin of the *Syssphingina* by both continuous and discontinuous evolution. The geographical distribution of the *Ceratocampinae*. The fore-tibial spur or epiphysis. The nomenclature of the veins of the Lepidoptera. Classification and life histories of *Ceratocampinae*.

II.—Anatomy, Physiology, and Development.

Britton, W. E.—Description of the Larva of *Delphastus pusillus*, Lec., with Notes on the Habits of the Species. Canad. Entomol., 1905, vol. xxxvii, pp. 185, 186, 1 fig.

Carpenter, F. W.—The Reactions of the Pomace Fly (*Drosophila ampelophila*, Loew.) to Light, Gravity and Mechanical Stimulation. Amer. Nat., 1905, vol. xxxix, pp. 157-171.

Cockerell, T. D. A. The Effect of Food on the Colour of Moths. Nature, 1906 (Feb. 8th), p. 341.

Dell, J. A.—The Structure and Life History of *Psychoda sexpunctata*, Curtis. Trans. Ent. Soc. Lond., 1905, pp. 293-311, text figs, 1-14.

The author has given an account of habitat and mode of life of this interesting Dipteron. The larva is described and figured, also its nervous system, alimentary canal, and respiratory system. The external features of the pupa, and its tracheal system are also described and figured, as well as the head and its appendages in the fly and the thorax and abdomen.

Del Guercio, G.—Contribuzione alla conoscenza delle metamorfosi della *Sciara analis*, Egg., con notizie intorno alla *Sc. analis* var. *bezzii*, v. n. ed ai loro rapporti con alcuni Sporozoari ed Entomozoari parassiti. Redia, 1905, vol. ii, pp. 280-315, 9 text figs.

Dyar, H. G.—Our Present Knowledge of North American Corethrid Larvae. Proc Entomol. Soc. Washington, 1905, vol. vii, pp. 13-16, figs. 1-6.

Dyar, H. G.—A Synoptic Table of North American Mosquito Larvae. Journ. N.Y. Entomol. Soc., 1905, vol. xiii, pp. 22-26.

Dyar, H. G.—Brief Notes on Mosquito Larvae. Ibid., pp. 26-29.

Dyar, H. G.—Illustrations of the Abdominal Appendages of Certain Mosquitoes. Ibid., pp. 53-56, 2 plts.

Girault, A. A.—Oviposition of *Bibio femorata*, Wied., and ovipositing females. Canad. Entomol., 1905, vol. xxxvii, pp. 322-330, 3 figs.

Girault, A.—Standards of the Number of Eggs laid by Insects. III. Being Averages obtained by actual count of the combined eggs from twenty (20) depositions or masses. Entom. News, 1905, vol. xvi, p. 167.

Marshall, Francis H. A., and **Jolly, William A.**—Contributions to the Physiology of Mammalian Reproduction. Pt. I. The Oestrous Cycle in the Dog. Pt. II. The Ovary as an Organ of Internal Secretion. Proc. Roy. Soc. Lond., 1905, Ser. B., vol. 75, pp. 395-398.

Minchin, E. A.—Report on the Anatomy of the Tsetse-fly (*Glossina palpalis*). Proc. Roy. Soc. Lond., 1905, Ser. B., vol. 76, pp. 531-547, text figs. 1-7.

Newstead, Robert.—On the External Anatomy of *Ornithodoros moubata*, Murray. Mem. XVII, Liverpool School Trop. Med., 1905, pp. 21-26, plts. i, ii.

Smith, J. B.—Vitality of Mosquito Eggs. Science, 1905 (n.s.), vol. xxi, pp. 266, 267.

Smith, J. B., and **J. A. Grossbeck.**—Descriptions of some Mosquito Larvae, with Notes on their Habits. Psyche, 1905, vol. xii, pp. 13-18.

Snodgrass, R. E.—The Hypopygium of the *Dolichopodidae*. Proc. Calif. Acc. Sc., 1904, vol. iii, Zool., pp. 273-294, 4 plts.

Pictet, A.—Influence de l'alimentation et de l'humidité sur la variation des papillons. Mém. Soc. Phys. Hist. nat. Genève, 1905, vol. xxxv, pp. 45-127, 5 plts.

Veneziani, A.—Valore morfologico e fisiologico dei Tubi Malpighiani. Redia, 1905, vol. ii, pp. 177-230, Tav. xviii-xx.

III.—Systematic and Geographical Distribution.

Baker, Carl F.—The Classification of the American Siphonaptera. Proc. U.S. Nat. Mus., 1905, vol. xxix, pp. 121-170.

This paper may be regarded as a supplement to the author's well-known Revision and a preliminary study of new material. It must prove of great service to all students of this group.

Berlese, Antonio.—Acari Nuovi. Manipulas IV. Acari di Giava. Redia, 1905, vol. ii, pp. 154-176, Tav. xv-xvii.

Berlese, Antonio.—Acari Nuovi. Manipulas V. Ibid., pp. 231-238.

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Cockerell, T. D. A.—A new Scale-Insect (Fam. Coccidae) on the Rose. Zool. Anz., 1905, Bd. xxix, pp. 514, 515.

Cockerell, T. D. A.—Notes on *Eulecanium folsomi*, King. Proc. Ent. Soc. Wash., 1906, vol. vii, pp. 129, 130.

Coquillett, D. W.—A new Cecedomyiid on Cotton. Canad. Entomol., 1905, vol. xxxvii, p. 200.

Corti, A.—Eriofidi nuovi o poco noti. Zool. Anz., 1905, Bd. xxviii, pp. 776-773, 2 figs.

Del Guercio, G.—Contribuzione alla conoscenza delle *Sipha*, Pass., ed alla loro posizione nella famiglia degli Afidi. Redia, 1905, vol. ii, pp. 127-153, Tav. xiii, xiv.

Farlow, W. G. Bibliographic Index of North American Fungi. Carnegie Inst. Washington, 1905, vol. i, pt. i, pp. xxxv + 312.

Howard, L. O.—Concerning the Geographic Distribution of the Yellow Fever Mosquito. Pub. Health Rpt. Washington, 1905, vol. xviii, no. 46, 9 pp., 1 map.

Nalepa, A.—Neue Gallmilben (28 Forsetzung). Sitz. Ak. Wien, 1905, No. xxv.

Rehn, J. A. G. Notes on Exotic Forficulids or Earwigs, with descriptions of new species. Proc. U.S. Nat. Mus., 1905, vol. xxix, pp. 501-515, 9 text figs.

IV.—Agricultural and Horticultural.

Arthur, J. C.—Rapid method of removing Smut from Seed Oats. Purdue Agric. Exp. Sta., Bull. 103, 1905, pp. 257-264.

Bessey, Ernst A.—A Nematode Disease of Grasses. Science, 1905 (n.s.), vol. xxi, pp. 391, 392.

Britton, W. E.—The Chief Injurious Scale-insects of Connecticut. Bull. Con. Agric. Exp. Stat., 1905, No. 151, 16 pp., 17 figs.

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Carleton, M. E.—Lessons from the Grain-Rust Epidemic of 1904. U.S. Dept. of Agric., Farmers' Bull. No. 219, 1905, pp. 1-24, 6 figs.

Carpenter, George H. Injurious Insects and other Animals observed in Ireland during the year 1904. Econ. Proc. Roy. Dub. Soc., 1905, vol. i, pp. 281-305, plts. xxiii-xxvi, text figs. 1-6.

Professor Carpenter's Report contains much valuable and interesting matter that cannot fail to be of service to agriculturists, fruit-growers, etc. The illustrations are particularly good, and bring out many points of interest to the student of insect morphology.

Chittenden, F. H.—The Dock False-worm. (*Taxonus nigrisoma*, Nort.). U.S. Dept. Agric., Div. of Entom., Bull. No. 54, pp. 40-43, 1 fig.

Chittenden, F. H.—The Larger Canna Leaf-roller. (*Calpodes ethlius*, Cram.). U.S. Dept. Agric., Div. of Entom., Bull. No. 54, pp. 54-58, 4 figs.

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Hedgcock, Geo. G.—A disease of cauliflower and cabbage caused by *Sclerotinia* [*libertiana*]. Rpt. Mis. Bot. Gard., 1905, pp. 149-151.

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Lounsbury, C. P.—Natural Enemies of the Fruit Fly. Agric. Journ. Cape Good Hope, 1905, vol. xxvi, pp. 84-87.

Mally, C. W.—The Mealie-stalk Borer. *Sesamia fusca*, Hampson. Agric. Journ. Cape Good Hope, 1905, vol. xxvii, pp. 159-168, 1 plt.

Marlatt, C. L.—The Giant Sugar-Cane Borer. (*Castnia licus, Fab.*). U.S. Dept. Agric., Div. of Entom., Bull. No. 54, 1905, pp. 71-75, 1 plt., 1 fig.

Perkins, R. C. L.—Leaf-hoppers and their Natural Enemies. Rpt. Work Exp. Stat. Hawaiian Sugar Plant. Ass., Div. of Entom., Bull. 1, 1905, pp. 71-85, 1 plt.

Slaus-Kantschieder, J.—Ueber Pflanzenkrankheiten im Gebiet von Spalato. Zeit. Land. Versuchsw. Oesterr., 1905, p. 274.

Smith, Erwin F.—Bacteria in Relation to Plant Diseases. Vol. i. 4to, pp. xii + 285, 31 plts. and 146 text figs. Washington: Carnegie Institution, 1905.

We welcome this beautifully printed and illustrated volume, which cannot fail to prove of great service to all investigators interested in plant diseases due to bacteria.

Quoting from Miquel and Cambier's well-known Treatise, it is stated that the list of bacteria capable of attacking the higher plants increases rapidly from day to day; but whether the experiments of plant pathology offer greater difficulties than those of animal pathology, or whether the authors who have undertaken them have ignored the multiple resources which bacteriology offers to-day, many of the species described must be studied anew, their monography offering regrettable lacunae.

The present volume contains an outline of methods of work, and it is proposed to treat of or touch upon, upwards of 125 diseases. There is a most comprehensive bibliography containing upwards of fifteen hundred titles.

W. E. C.

Turner, H. J.—Note on the Rush-feeding Coleophorids. Entom. Rec. Journ. Var., 1905, vol. xvii, pp. 286, 287.

V.—Forestry.

Curtis, Charles E.—Elementary Forestry. Demy 8vo. Pp. xxiv + 318, 1 plt. and 62 text figs. London: "Estates Gazette," Ltd. [1905].

To produce even an elementary work on forestry and illustrate the same in the space of 318 printed pages is by no means an easy task, and while there is much in Mr. Curtis's book that is treated very briefly, in fact, insufficiently to be of much value, the bulk of it is well written and exceedingly practical. Further, a word of praise must be given to the manner in which the subject matter is presented. The work is divided into eight sections, containing 46 chapters. The first section treats of soils, manures, drainage, etc.; the second, of the biology of arborescent plants, propagation, planting, etc.; the third, of management, measurement, and realisation; section four treats of the identification of forest trees; five, of the British forest trees; six is devoted to the *Coniferae*, whilst seven and eight contain the barest outlines of insect pests and fungi injurious to forest trees.

The work can be recommended to those possessing no previous knowledge of the subject as an interesting and useful introduction.

W. E. C.

VI.—Fisheries.

VII.—Medical.

Condorelli, M.—Caso di myiasis, nell' uomo per larva cuticolare di *Hypoderma bovis* (De Geer). Boll. Soc. Zool. Ital., 1904, Ann. xiii, pp. 171-181.

Doty, A. H.—The use of Sulphate of Copper alone, and in combination with Lime, for the destruction of Mosquito Larvae, as a Deodorant, and as a Disinfectant. Med. Rec. N.Y., 1905, vol. lxvii, pp. 90-92.

Dutton, J. E., and Todd, J. L. The Nature of Human Tick-Fever in the Eastern part of the Congo Free State, with notes on the Distribution and Bionomics of the Tick. Mem. xvii, Liverpool School Trop. Med., 1905, pp. 1-18, plts. iii, iv, and map and charts.

Dutton, J. E., and Todd, J. L.—Gland Puncture in Trypanosomiasis. Ibid., pp. 97-102, figs. 1-3.

Eberle, H. A. The problem of exterminating Mosquitoes; discovery of inaccessible breeding places. New York Med. Journ., 1905, vol. lxxxi, pp. 848, 849.

Herzog, M.—Suctorial and other Insects as Plague Carriers. A new species of Rat flea. Amer. Journ. Med. Sc., 1905, vol. cxxix, pp. 504-520, 10 figs.

Marchoux, E., et P. L. Simond. La transmission héréditaire du virus de la fièvre jaune chezle *Stegomyia fasciata*. C. R. Soc. Biol. Paris, 1905, T. lix, pp. 259, 260.

Nabarro, D., and E. D. W. Greig. Further Observations on the Trypanosomiases (Human and Animal) in Uganda. Rpt. Sleeping Sickn. Comm. R. Soc. Lond., 1905, No. 5, pp. 8-47, 3 plts.

Thomas, H. W., and Breinl, A. Trypanosomes, Trypanosomiasis, and "Sleeping Sickness." Memoir xvi, Liverpool School Trop. Med., 1905, pp. 1-94, plts. i-vi, and 7 charts.

Towle, H. P.—The Brown Tail Moth Eruption. Boston Med. Surg. Journ., 1905, vol. clii, pp. 74-76.

VIII.—Veterinary.

Schroeder, E. C.—Studies in Immunity from Tuberculosis. U.S. Dept. of Agric., Bur. of An. Indus., Bull. No. 52, 1905, pp. 101-114.

Schroeder, E. C., and Cotton, W. E.—The Persistence of Tubercle Baccili in Tissues of Animals after Injection. Ibid., pp. 115-125.

Stevenson, E. C.—The External Parasites of Hogs. U.S. Dept. of Agric., Bur. of An. Indus., Bull. No. 69, 1905, pp. 1-44, 29 figs.

Treats of *Haematopinus suis* (L.), *Sarcoptes scabiei* var *suis*, and *Demodex folliculorum* var. *suis*. A very complete bibliography is given.